EG&G

INSTRUCTION MANUAL

NUMBER B-3443A
1 AUGUST 1968

MODEL 580 RADIOMETER
MODEL 580/585
SPECTRORADIOMETER

MP MASTER
MA29010

ELECTRONIC PRODUCTS DIVISION
EG&G, INC., 160 BROOKLINE AVE., BOSTON, MASSACHUSETTS 02215

Digitized by the Internet Archive
in 2026

https://archive.org/details/manualsplus_13180

EG&G

INSTRUCTION MANUAL

NUMBER B-3443A
1 AUGUST 1968

MODEL 580 RADIOMETER
MODEL 580/585
SPECTRORADIOMETER

Revised 1 August 1968

ELECTRONIC PRODUCTS DIVISION
EG&G, INC., 160 BROOKLINE AVE., BOSTON, MASSACHUSETTS 02215

Section			Page
1	DESCRIPTION OF SYSTEMS		1-1
	1.1	Introduction	1-1
	1.2	Model 580 Radiometer System	1-4
	1.3	Model 580/585 Spectroradiometer System	1-4
	1.4	Spectroradiometer with Model 585-66, -63 High-Sensitivity Detector Heads	1-7
2	DESCRIPTION OF COMPONENTS		2-1
	2.1	General	2-1
	2.2	Model 580-11A Indicator Unit (Model 580 Radiometer and Model 580/585 Spectroradiometer Systems)	2-1
	2.3	Model 580-20A Series Detector Heads (Models 580 Radiometer and 580/585 Spectroradiometer Systems)	2-4
	2.4	Model 585-30 Series Beam Input Optics (Model 580/585 Spectroradiometer)	2-9
	2.5	Model 585-11 Monochromator Housing (Model 580/585 Spectroradiometer)	2-9
	2.6	Model 585-20 Series Gratings (Model 580/585 Spectroradiometer)	2-11
	2.7	Model 585-20-20 Series Fixed Slits (Model 580/585 Spectroradiometer)	2-12
	2.8	Model 585-00-11 Adapter (Model 580/585 Spectroradiometer)	2-13
	2.9	Model 585-00-12 Adapter (Model 580/585 Spectroradiometer)	2-13
	2.10	Model 580-00-31 Photometric Filter (Model 580 Radiometer and Model 580/585 Spectroradiometer Systems)	2-13
	2.11	Model 585-20-10 Series Filters (Model 580/585 Spectroradiometer)	2-14
	2.12	Model 580-32 Hooded Filter Holder (Model 580 Radiometer and Model 580/585 Spectroradiometer System	2-15
	2.13	Model 585-60 Series High-Sensitivity Detector Heads (Model 580/585 Spectroradiometer)	2-16
	2.14	Model 585-00-60 Power Supply (Model 580/585 Spectroradiometer)	2-18
	2.15	Model 585-00-63 Controller (Model 580/585 Spectroradiometer)	2-18
3	DESCRIPTION OF ACCESSORIES		3-1
	3.1	General	3-1
	3.2	Model 580-00-11 Narrow-Beam Adapter/Laser Attenuator (Model 580 Radiometer System)	3-1
	3.3	Model 580-00-12 Laser-Beam Sampler (Model 580 Radiometer)	3-2
	3.4	Model 585-20-24 Variable Slits (Model 580/585 Spectroradiometer)	3-2

Section			Page
	3.5	Model 585-11-11 Wavelength Transducer (Model 580/585 Spectroradiometer System	3-2
4		OPERATING INSTRUCTIONS	4-1
	4.1	Model 580 Radiometer System Operation	4-1
	4.2	Model 580/585 Spectroradiometer Operation	4-6
	4.3	Model 585-11-11 Wavelength Transducer	4-9
	4.4	Model 580/585 Spectroradiometer System (Model 585-60 Series High-Sensitivity Detector Heads, Figures 19, 20, 29, 30)	4-10
5		CALIBRATION	5-1
	5.1	General	5-1
	5.2	Model 580 Radiometer Calibration	5-1
	5.3	580/585 Spectroradiometer Calibration	5-5
6		MAINTENANCE	6-1
	6.1	General	6-1
	6.2	Cleaning	6-1
	6.3	Schematics	6-1
	6.4	Equipment Return	6-1

Figure		Page
1	Basic Model 580 Radiometer System	1-2
2	Basic Model 580/585 Spectroradiometer System	1-2
3	Model 580/585 Spectroradiometer System Using a Model 585-66 High-Sensitivity Detector Head	1-3
4	Model 580/585 Spectroradiometer System Using a Model 585-63 High-Sensitivity Detector Head	1-3
5	Functional Block Diagram of a Radiometer	1-5
6	Functional Block Diagram of a Spectroradiometer	1-6
7	Minimum-Maximum Sensitivity Levels of Model 580/585 Spectroradiometer Systems	1-6
8	Model 580-11A Indicator Unit	2-1
9	Model 580-20A Series Detector Head	2-5
10	Model 580-20A Series Detector Head Operational Schematics	2-7
11	Model 585-30 Series Beam Input Optics	2-9
12	Optical Schematic of a Spectroradiometer	2-10
13	Model 585-11 Monochromator Housing	2-10
14	Model 585-20 Series Grating	2-12
15	Model 585-20-20 Series Fixed Slits	2-13
16	Model 585-00-11 Adapter	2-13
17	Model 580-00-31 Photometric Filter	2-14
18	Model 580-32 Hooded Filter Holder with Model 585-20-10 Series Filters	2-15
19	Model 585-66 High-Sensitivity Detector Head (Model 585-00-60 Power Supply, A Separate System Component, Also Shown to Illustrate Mounting)	2-16
20	Model 585-63 High Sensitivity Detector Head	2-16
21	Model 585-00-63 Controller Mounted on Model 585-00-60 Power Supply in Infrared Measurement Configuration	2-18
22	Model 580-00-11 Series Narrow-Beam Adapter/Laser Attenuator	3-1
23	Model 580-00-12 Laser-Beam Sampler	3-2
24	Model 585-20-24 Variable Slits	3-2
25	Model 585-11-11 Wavelength Transducer	3-3
26	Equipment Setup for a Direct Plot of Wavelength Versus Intensity	3-3
27	Ohmmeter Connection	4-10
28	Wavelength Transducer Alignment	4-10
29	Model 585-63 Detector Head (Showing Controls)	4-11
30	Model 585-66 Detector Head (Uncoupled from Power Supply)	4-11
31	Shutter Controls	4-12

Figure		Page
32	Minimum Pulse Width; Model 585-66 Detector Head	4-17
33	Minimum Pulse Width; Model 585-63 Detector Head	4-17
34	Typical Model 580-20A Series Detector Head Calibration Certificate	5-1
35	Typical Model 580-20A Series Detector Head Side Calibration Plate	5-1
36	Typical Model 580-00-11 Narrow-Beam Adapter Calibration Certificate	5-4
37	Typical Model 580/585 Spectroradiometer Calibration Certificate	5-6
38	Schematic Diagram, Model 580-20A Series Detector Heads	6-1
39	Schematic Diagram, Model 580-11A Indicating Unit	6-3
40	Schematic Diagram, Model 585-66 High-Sensitivity Detector Head	6-5
41	Schematic Diagram, Model 585-63 High-Sensitivity Detector Head	6-7
42	Schematic Diagram, Model 580-00-60 Power Supply	6-9
43	Schematic Diagram, Model 585-00-63 Controller	6-11
44	Model 585-11-11 Wavelength Transducer	6-13

1.1 INTRODUCTION

EG&G, Inc., makes available three basic systems to measure or characterize the spectral output of pulsed or steady light sources. These are:

(1) The Model 580 Radiometer System (Figure 1).

(2) The Model 580/585 Spectroradiometer System (Figure 2).

(3) The Model 580/585 Spectroradiometer System using a Model 585-66 or 585-63 High-Sensitivity Detector Head (Figures 3 and 4).

Each of these three basic systems is discussed in this section. For quick, detailed reference (and the elimination of duplication) the major components of the various system configurations are discussed separately (see Section 2). Table 1 lists

Table 1. Radiometer and Spectroradiometer System Configurations.

Components	Model 580 Radiometer			Model 580/585 Spectroradiometer				Model 580/585 Spectroradiometer High Sensitivity			
	S1	S5	S20	S1	S5*	S5**	S20	S1	S10*	S10**	S10***
Model 580-11A Indicator Unit	x	x	x	x	x	x	x	x	x	x	x
Model 580-22A Detector Head			x				x				
Model 580-23A Detector Head	x			x							
Model 580-25A Detector Head		x			x	x					
Model 585-63A Detector Head								x			
Model 585-66 Detector Head									x	x	x
Model 585-00-60 Power Supply								x	x	x	x
Model 585-00-63 Controller								x			
Model 580-32 Hooded Filter Holder	x	x	x	x	x	x	x	x	x	x	x
Model 580-00-31 Photometric Filter		x			x	x					
Model 585-11 Monochromator Housing				x	x	x	x	x	x	x	x
Model 585-22 Grating					x		x		x		x
Model 585-23 Grating				x				x			
Model 585-24 Grating					x	x			x	x	
Model 585-20-21 Fixed Slits (3.00 mm Exit)				x	x	x	x	x	x	x	x
Model 585-20-22 Fixed Slits (1.50 mm Exit)				x	x	x	x	x	x	x	x
Model 585-20-23 Fixed Slits (0.75 mm Exit)				x	x	x	x	x	x	x	x
Model 585-20-24 Variable Slits				0	0	0	0	0	0	0	0
Model 585-20-11 Filter					x		x		x		x
Model 585-20-12 Filter					x		x		x		x
Model 585-20-13 Filter				x				x			
Model 585-20-15 Filter					x	x			x	x	
Model 585-31 Beam Input Optics				x			x	x			x
Model 585-32 Beam Input Optics				0	x	x	0	0	x	x	0
Model 585-00-11 Adapter (580/585)				x	x	x	x		x	x	x
Model 585-00-12 Adapter				0	0	0	0	x	0	0	0
Model 580-00-11 Narrow-Beam Adapter	0	0	0	0	0		0	0	0		0
Model 580-00-12 Laser-Beam Sampler	0	0	0	0	0		0	0	0		0
Model 585-11-11 Wavelength Transducer				0	0	0	0	0	0	0	0

x Standard
0 Optional

*UV and Visible
**UV only
***Visible only

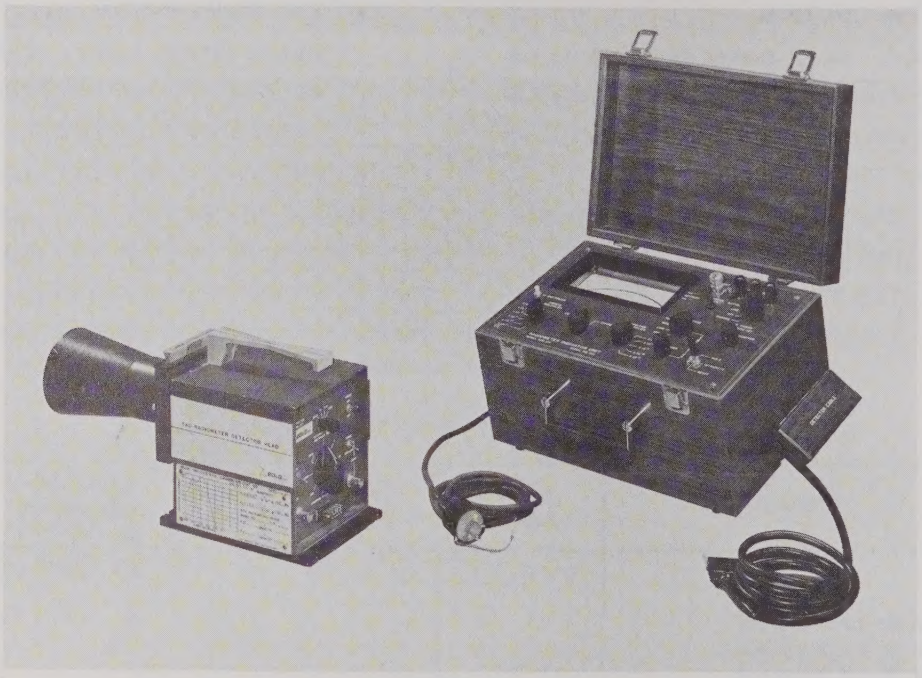


Figure 1. Basic Model 580 Radiometer System.

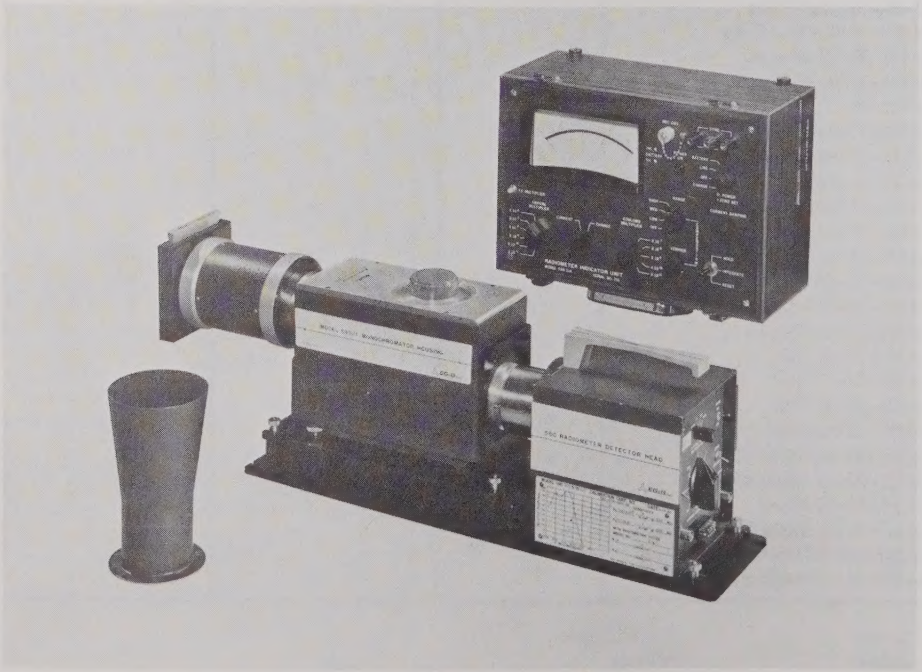


Figure 2. Basic Model 580/585 Spectroradiometer System.

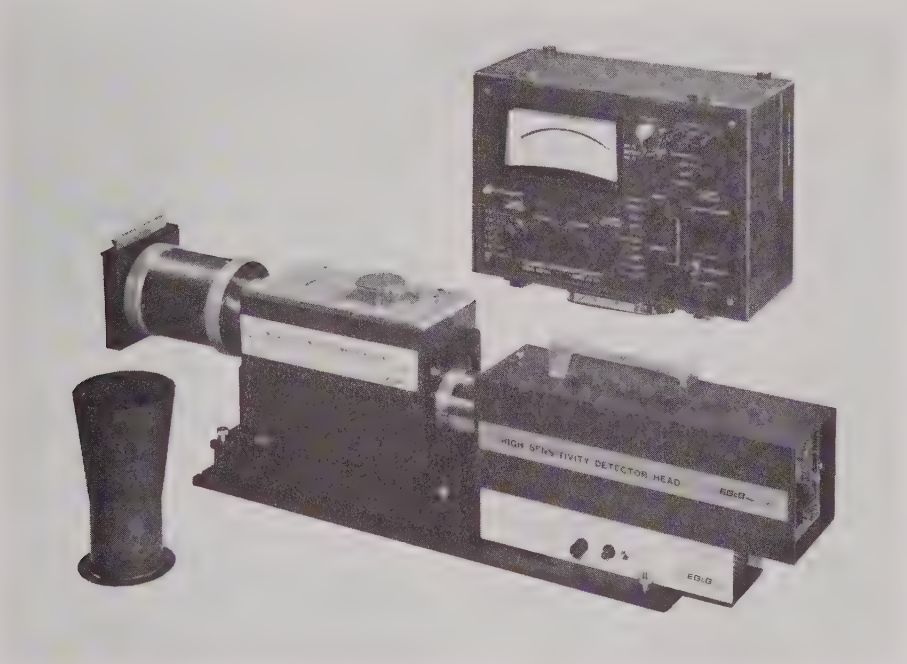


Figure 3. Model 580/585 Spectroradiometer System Using a Model 585-66 High-Sensitivity Detector Head.

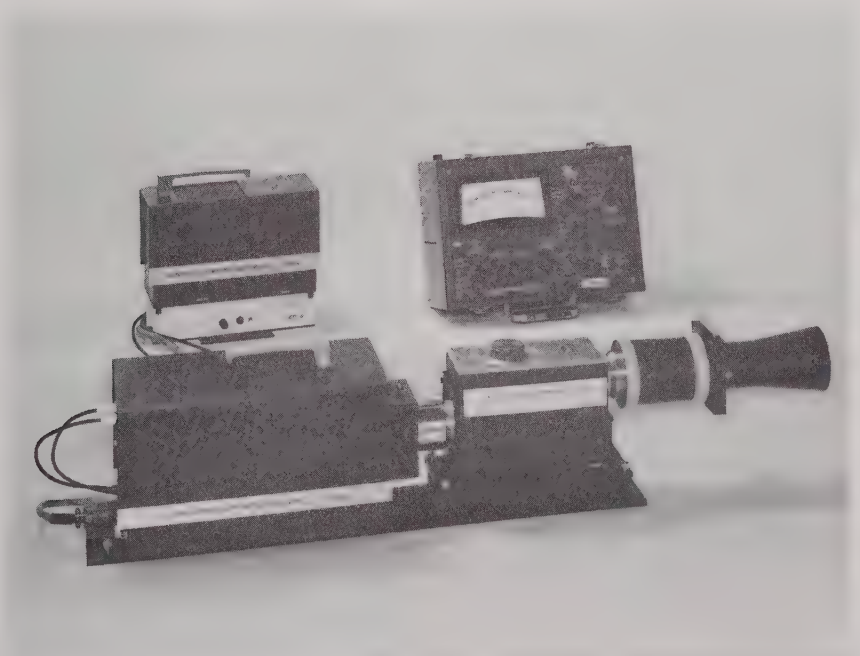


Figure 4. Model 580/585 Spectroradiometer System Using a Model 585-63 High-Sensitivity Detector Head.

the major components and indicates which components are associated with each system.

NOTE

Keep in mind throughout these instructions that many components are common to more than one system.

1.2 MODEL 580 RADIOMETER SYSTEM

The EG&G Model 580 Radiometer System (Figure 1) is a compact, portable, and versatile assemblage of precision instruments designed for the quantitative measurement of steady-state or pulsed light. It is capable of making direct measurements, with meter and recorder readout, of average power of continuous light sources and total integrated energy of pulsed-light sources. Provision has been made to use an oscilloscope for output measurements of peak power and waveform of pulsed events.

The basic Model 580 Radiometer System consists of the following components (see also Table 1):

(1) Model 580-11A Indicator Unit

(2) Model 580-20A Series Detector Head

(3) Model 580-00-31 Photometric Filter (used only with Model 580-25A Detector Head)

(4) Model 580-32 Hooded Filter Holder

The following accessories may be purchased for use with the Model 580 Radiometer System.

(1) Model 580-00-11 Narrow-Beam Adapter/Laser Attenuator

(2) Model 580-00-12 Laser-Beam Sampler

The versatility of the Model 580 Radiometer System has led to a wide variety of applications in areas of light-source evaluation and laser measurements. The system covers the complete spectral range from 200 millimicrons (nanometers) in the ultraviolet region to 1200 millimicrons in the near infrared, including all the visible region. It is designed for measurement of both continuous light sources and pulsed-light sources (the latter having risetimes as fast as 1 nanosecond). It has a linear dynamic-response range of over 12 decades. The absolute accuracy is ±8% in the visible and IR regions, and ±15% for the UV. Relative accuracy is better than 1%.

The Model 580-20A Series Detector Head houses a photodiode, an aperture system, and a diffuser disc. Provision is made for tripod mounting, detector alignment, and output terminals for oscilloscope display of pulsed-light waveform signals. Figure 5 shows a functional block diagram of a Radiometer.

1.3 MODEL 580/585 SPECTRORADIOMETER SYSTEM

The Model 580/585 Spectroradiometer System (Figure 2) facilitates measurement of chromatic light sources of unknown spectral output without resorting to a series of expensive filters. This system allows the user to make the same absolute measurements of average power, integrated energy, peak power, and pulse shape at any desired wavelength with a discrete known bandwidth.

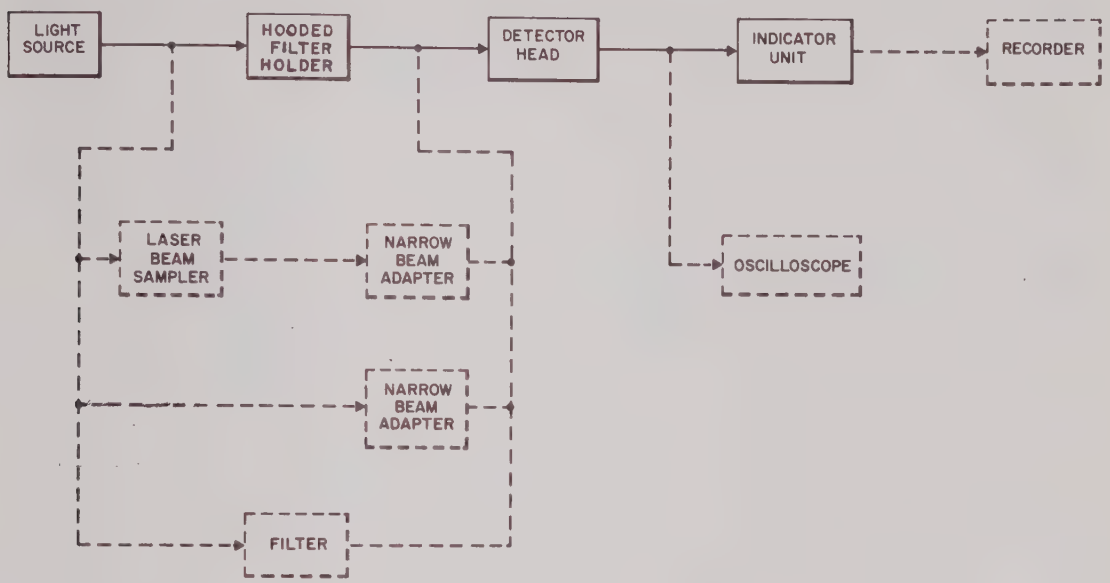


Figure 5. Functional Block Diagram of a Radiometer.

(The total absolute power or energy of a chromatic source is the summation of the incremental power and energy at each wavelength.)

The basic Model 580/585 Spectroradiometer System consists of the following components:

(1) Model 580-11A Indicator Unit
(2) Model 580-20A Series Detector Head
(3) Model 585-30 Series Beam Input Optics
(4) Model 585-11 Monochromator Housing
(5) Model 585-20 Series Gratings
(6) Model 585-20-20 Series Fixed Slits
(7) Model 585-00-11 Adapter (or 585-00-12 Adapter)
(8) Model 585-20-10 Series Filters
(9) Model 580-32 Hooded Filter Holder

The following accessories may be purchased for use with the Model 580/585 Spectroradiometer System (see also Table 1):

(1) Model 580-00-11 Narrow-Beam Adapter/Laser Attenuator
(2) Model 580-00-12 Laser-Beam Sampler
(3) Model 585-20-24 Variable Slits
(4) Model 585-11-11 Wavelength Transducer

The Model 580/585 Spectroradiometer has the facility for oscilloscope display of peak-power and waveshape measurements at any desired wavelength with a finite bandwidth. The Model 580-20A Series Detector Head is easily demountable and can readily be used as a basic Radiometer System. Figure 6 shows a functional block diagram of a Spectroradiometer and Figure 7 provides a graphic representation of

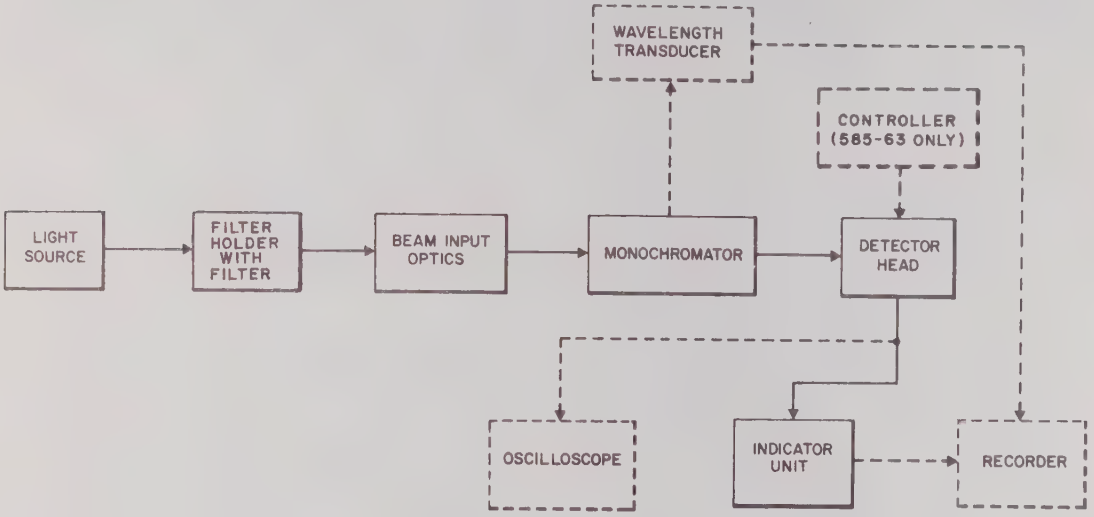


Figure 6. Functional Block Diagram of a Spectroradiometer.

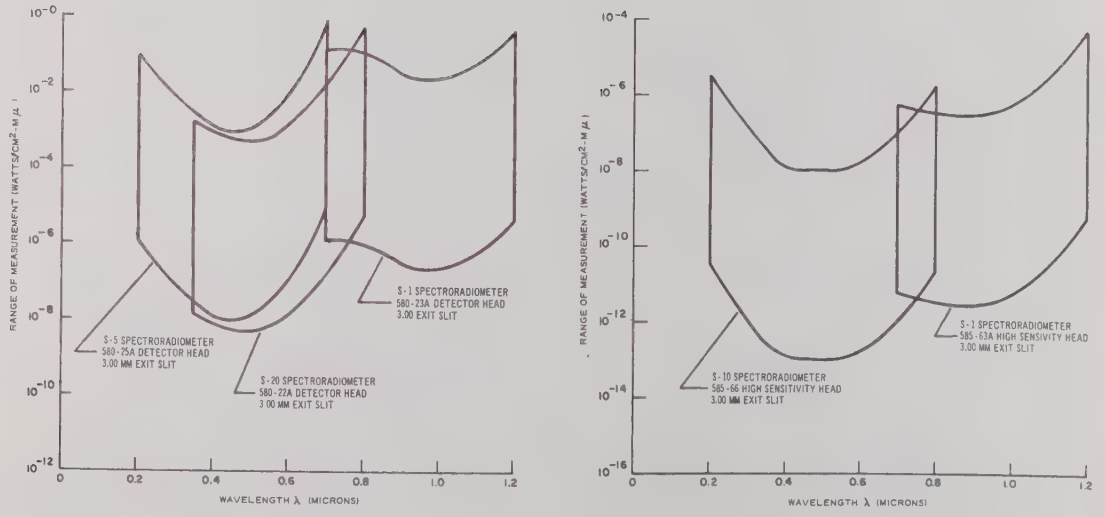

RANGE OF MEASUREMENT (WATTS/CM2-M μ)
WAVELENGTH λ (MICRONS)
S-5 SPECTRORADIOMETER 580-25A DETECTOR HEAD 3.00 MM EXIT SLIT
S-20 SPECTRORADIOMETER 580-22A DETECTOR HEAD 3.00 MM EXIT SLIT
S-1 SPECTRORADIOMETER 580-23A DETECTOR HEAD 3.00 EXIT SLIT
S-10 SPECTRORADIOMETER 585-66 HIGH SENSITIVITY HEAD 3.00 MM EXIT SLIT
S-1 SPECTRORADIOMETER 585-63A HIGH SENSIVITY HEAD 3.00 MM EXIT SLIT

Figure 7. Minimum-Maximum Sensitivity Levels of Model 580/585 Spectroradiometer Systems.

minimum-maximum sensitivity levels using various Detector Heads (including the Model 585-60 Series High-Sensitivity Heads, subsection 1.4).

1.4 SPECTRORADIOMETER WITH MODEL 585-66, -63 HIGH-SENSITIVITY DETECTOR HEADS

The Model 585-66 or Model 585-63 High-Sensitivity Detector Head is used with the Model 580/585 Spectroradiometer System to allow absolute measurements of low-intensity, pulsed or CW, light signals (see Figures 3, 4, and 6). These Detector Heads incorporate photomultiplier tubes to provide approximately five decades of additional system sensitivity over that furnished by the Model 580-20A Series Detector Heads.

The Model 585-66 High-Sensitivity Detector Head encompasses a spectral range from 200 to 750 millimicrons (ultraviolet and visible) and senses irradiant powers as low as 1×10^{-13} watt/cm^2-mμ and irradiant energies as low as 1×10^{-13} joule/cm^2-mμ at 450 millimicrons (nanometers).

The basic Model 580/585 Spectroradiometer System utilizing the Model 585-66 Detector Head consists of the following additional components (see also Table 1):

(1) Model 580-11A Indicator Unit
(2) Model 585-00-60 Power Supply
(3) Model 585-30 Series Beam Input Optics
(4) Model 585-11 Monochromator Housing
(5) Model 585-20 Series Gratings
(6) Model 585-20-20 Series Fixed Slits
(7) Model 585-00-11 Adapter (or 585-00-12 Adapter)
(8) Model 585-20-10 Series Filters
(9) Model 580-32 Hooded Filter Holder

The following accessories may be purchased for use with the foregoing Model 585-66 version of the Spectroradiometer System:

(1) Model 585-20-24 Variable Slits
(2) Model 585-11-11 Wavelength Transducer
(3) Model 580-00-11 Narrow-Beam Adapter/Laser Attenuator*
(4) Model 580-00-12 Laser-Beam Sampler*

The Model 585-63 High-Sensitivity Detector Head encompasses a spectral range from 700 to 1200 millimicrons (near infrared) and detects irradiant powers as low as 5×10^{-12} watt/cm^2-mμ and irradiant energies as low as 5×10^{-12} joule/cm^2-mμ at 800 millimicrons.

The basic Model 580/585 Spectroradiometer System utilizing the Model 585-63 Detector Head consists of the following additional components (see also Table 1):

(1) Model 580-11A Indicator Unit
(2) Model 585-00-60 Power Supply
(3) Model 585-00-63 Controller
(4) Model 585-30 Series Beam Input Optics

*High-Sensitivity Detector Heads can also be used as Radiometers; therefore laser-related accessories are included in list.

(5) Model 585-11 Monochromator Housing

(6) Model 585-23 Gratings

(7) Model 585-20-20 Series Fixed Slits

(8) Model 585-00-12 Adapter

(9) Model 585-20-13 Filter

(10) Model 580-32 Hooded Filter Holder

The following accessories may be purchased for use with the foregoing Model 585-63 version of the Spectroradiometer System:

(1) Model 585-20-24 Variable Slits

(2) Model 585-11-11 Wavelength Transducer

(3) Model 580-00-11 Narrow-Beam Adapter/Laser Attenuator*

(4) Model 580-00-12 Laser-Beam Sampler*

Energy and average power measurements with the two high-sensitivity configurations are obtained directly from the multi-decade meter of the Model 580-11A Indicator Unit or from an external recorder.

Provision is also made for output to an oscilloscope for pulsed sources. Applications with the high-sensitivity configurations include measurements of phosphors, chemical reaction, electroluminescence emissivity and reflectivity of surfaces, biochemical analysis, and other low-level signals.

*High-Sensitivity Detector Heads can also be used as Radiometers; therefore laser-related accessories are included in list.

2.1 GENERAL

This section contains a description of each component of the three (para 1.1) basic systems and an explanation of its principal operational features. Illustrations of each component are provided. The major components (physically) are discussed first, followed by the peripheral items (adapters, filters, holder, viewing hood), and finally by the High-Sensitivity Detector Heads which are essentially specialized range-extending additions to the basic Model 580/585 Spectroradiometer System configuration.

2.2 MODEL 580-11A INDICATOR UNIT (MODEL 580 RADIOMETER AND MODEL 580/585 SPECTRORADIOMETER SYSTEMS)

General

The Model 580-11A Indicator Unit (Figure 8) is used with all Radiometer and Spectroradiometer Systems. It serves three purposes: charge-current indication, system control panel, and power supply. The Detector Head interconnecting cable and power cable are stored for easy access through spring-lock ports in the side of the case. The Indicator Unit can be energized from external power or by the internal battery at the option of the operator. A two-minute warm-up time stabilizes all circuits.

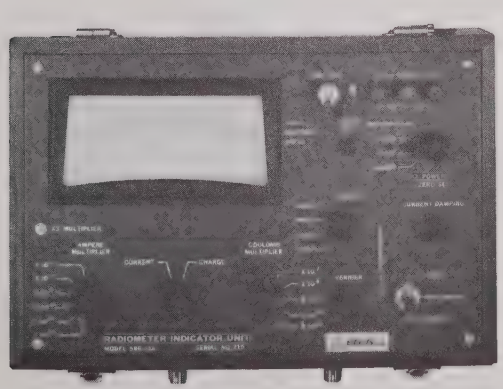


Figure 8. Model 580-11A Indicator Unit.

Characteristics

(1) Charge Scales: 10×10^{-11} to 10×10^{-7} coulomb (5 individual switch positions)

(2) Current Scales: 10×10^{-11} to 10×10^{-6} ampere (6 individual switch positions)

(3) Ambient Compensation: Low, medium, high, with vernier (compensates for net effect of ambient light level and detector leakage). Maximum compensation current available is more than 4 μA.

(4) Pulse Minimums for Energy Measurement (Meter): 10.0 nanosecond pulse width min. 1.0 ns rise-time min.

(5) Power Requirements: 117 volts, 50 to 60 Hz or 230 volts, 50 to 60 Hz as specified by customer (operator's choice of external power or internal rechargeable battery operation).

(6) Battery Operating Time: 6 to 8 hours (depending on amount of ambient compensation needed).

(7) Battery Recharge Time: 8 hours

(8) Battery Life: 1 year (minimum)

(9) Dimensions: 13 in. long x 8 in. wide x 10 in. deep

(10) Weight: 15 lb

Controls and Readout

The Indicator Unit provides a broad measurement flexibility with a minimum number of controls and a maximum ease of operation. Control markings are easily readable, and all detent switches have pointer-type knobs for absolute position indication. The following subsection explains in detail the function of each control.

(1) POWER switch: The four-position switch selects method of energizing System. Operation from an external a-c source or an internal battery is at user's option.

a. OFF position: All power to System shut off. POWER ON indicator lamp not lit.

b. LINE position: External line voltage applied; System energized. POWER ON lamp blinks; meter illuminated. Internal battery charges.

c. BATTERY position: Internal battery voltage applied; System energized. POWER ON lamp blinks; meter not illuminated.

d. CHARGE position: External line voltage charges battery. POWER ON lamp and meter scale illuminated.

(2) BATTERY indicators: The two indicators show condition of internal rechargeable battery.

a. CHG indicator: Hue changes from red at full-charge condition to colorless at no charge.

b. DIS indicator: Hue changes from red at no-charge condition to colorless at full charge.

NOTE

Rate of battery drain depends on ambient light conditions encountered. Limited experience will permit reasonable operator judgements of remaining time for battery operation and/or remaining time to acquire full battery charge.

(3) "Function" switch: The two-position switch selects steady-light measuring circuit (current) or pulsed-light measuring circuit (charge).

a. CURRENT position: Used for steady-light-source measurements. Connects current-measuring circuits to meter for measurement of average signal power.

b. CHARGE position: Used for pulsed-light-source measurements. Connects charge-measuring circuits to meter for measurement of integrated signal energy.

(4) AMPERE MULTIPLIER switch: Six-position switch to select proper meter scale when "function" switch is in CURRENT position.

(5) COULOMB MULTIPLIER switch: Five-position switch to select proper meter scale when "function" switch is in CHARGE position.

(6) INTEGRATE switch: Three-position switch controls measurement of a pulsed light event. It can be used with three synchronizing terminals (labeled SYNC) on front panel to initiate a pulsed-light event. A single-pole double-throw switch (S7), operated mechanically by the INTEGRATE switch, acts as a synchronizing trigger. In the RESET position, the N. O. terminal is disengaged from the SYNC connector, which is engaged with the N. C. terminal. When the INTEGRATE switch is placed in INTEGRATE position, the SYNC terminal shorts to the N. O. terminal and the N. C. terminal is opened. This trigger technique minimizes any uncompensated error due to preflash integration of ambient light in pulsed-light measurements. It also eliminates the uncertainty of manual synchronization of measurement in pulsed-light events, except for those of random nature which cannot be triggered.

NOTE

A smooth manual push action from RESET position through INTEGRATE position to HOLD position is the proper operating technique for this switch when measuring pulsed light.

a. RESET position: Discharges integrating circuits and returns meter needle to zero in preparation for measurement of a flash event. Position is normal one for all current measurements.

b. INTEGRATE position: Places integrating circuits in "ready" status for time-integrated light measurements. Same as RESET for current measurements.

c. HOLD position: Disconnects detector circuit after meter displays final reading of pulsed-light event to permit accurate observation. Meter drift rate in HOLD is less than 0.1% full scale in 15 seconds. Position also used for setting meter zero in CURRENT position for all measurements.

(7) ZERO SET potentiometer: Located on POWER switch. Establishes electrical zero on meter prior to light measurements.

(8) COMPENSATION controls: Nullify effects of normal steady ambient light and also compensate leakage so that source measurements are essentially direct reading, even in sunlight.

a. RANGE switch: Selects compensation range needed to nullify effects of normal ambient light. Since three current scales (low, medium, and high) overlap, correct setting is quickly determined.

b. VERNIER potentiometer: Fine adjustment for zeroing meter indication. Operates in conjunction with RANGE switch.

(9) "Measurement Indicator Meter": Microammeter with 0.5% tracking accuracy. Construction incorporates a taut band suspension which eliminates hysteresis and binding problems. The top scale on the meter face is marked from 0 to 10 and the bottom scale on the meter face is marked from 0 to 3. These major scale divisions are further divided into tenths by easily read scale markings. Meter is direct reading in amperes or coulombs as determined by position of "function" switch and associated scale setting.

(10) X3 MULTIPLIER control: Expands meter scale indication and REC OUT voltage to allow using 0-to-3 instead of 0-to-10 scale.

(11) REC OUT connector: The recorder output is a bias voltage of 10 mv for full-scale meter deflection. The REC OUT signal can be used with the Wavelength Transducer to give an X-Y plot of signal intensity vs wavelength. Impedance of this output is 200 ohms.

(12) CURRENT DAMPING potentiometer: An averaging device to dampen out small noise fluctuations of signal (from an unsteady source or from variations in ambient light). Also gives average value of a train of pulses in current mode. Can be used for steadying out noise fluctuations with High-Sensitivity Heads at extremely low levels. Works on all current scales except X 10^{-6}.

2.3 MODEL 580-20A SERIES DETECTOR HEADS (Models 580 Radiometer and 580/585 Spectroradiometer Systems)

General

All Model 580-20A Series Detector Heads (Figure 9) are basically the same. The difference in the designations (-21, -22, etc.) of the Detector Heads is based on the particular range of spectral response. This range is determined by the specific biplanar photodiode used in the Head (S1, S20, etc.). Each Head also has a diffuser disc, either opal glass (visible and IR) or a pair of ground-quartz pieces (UV), a variable-aperture system with trimming potentiometers, and circuitry for input and output signals.

Optics

The Detector Head has a very simple optics system in that the incident light illuminates the diffuser (full illumination is necessary for calibrated readings) which accepts 100% of the energy within a 14-degree cone. (This acceptance then drops off beyond this.) The Model 580-32 Hooded Filter Holder is constructed to eliminate any light outside this 14-degree cone. The variable apertures simply select what portion of the diffuser the photodiode senses. Therefore, since the photodiode is

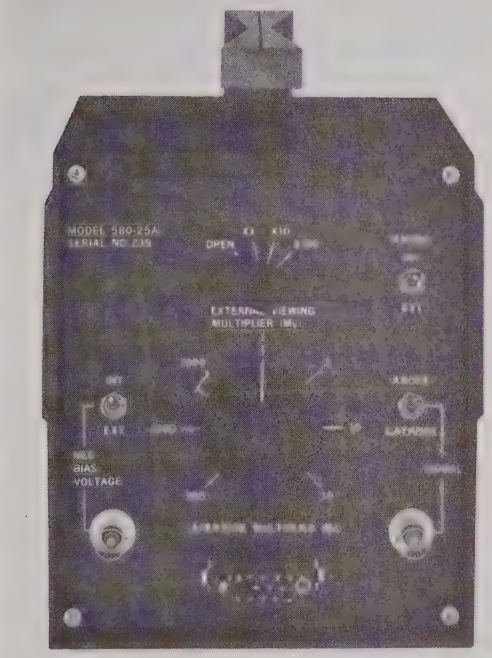


Figure 9. Model 580-20A Series Detector Head.

always fully illuminated, there is no problem with surface linearity. There are eight steps of attenuation (or eight different aperture openings) in the aperture-disc system, with the 1-position looking at the whole diffuser and the 3000-position looking at a very small portion of the diffuser. The apertures are made as accurately as possible in the ratios of 1 to 3000 but this still can give ratio errors of up to about 8%. To correct for this mechanical mismatch there are trimmer potentiometers in the Detector Head which put an additional electrical signal into the current summing junction of the Model 580-11A Indicator Unit to correct aperture settings to within 1%. If the Indicator Unit is not used with the Detector Head, then the correction is not made in the 3 through 3000 positions. (The photodiode itself is energized from the Indicator Unit or an external source and acts as a linear current generator with output dependent on the intensity of the incident light.)

Functional Controls

All controls of the Detector Heads are located on the rear panel for ease of operation and readability. Both detent switches have pointer-type knobs for absolute position indication. The following subsection explains in detail the function of each control:

(1) NEG BIAS VOLTAGE switch (S3): This two-position switch selects method of biasing photodiode.
   a. INT position: Biases photodiode with -150 volt power supply in Indicator Unit.
   b. EXT position: Allows biasing of photodiode (up to 1000 volts) with any suitable external d-c power supply through BNC type connector (J2).

(2) ANODE switch: Provides a means to monitor anode output current signal either with Indicator Unit or an external oscilloscope.
   a. INT position: Photodiode current signal is measured with Indicator Unit.
   b. EXT position: Output current signal is measured with external instruments - see NOTE, item (5) below.

(3) SIGNAL switch: Provides a means to monitor output current signals from either anode or cathode of the photodiode.

a. ANODE position: Output current signal is taken from anode of photodiode.

b. CATHODE position: Output signal is taken from signal developed across 100k ohms in cathode circuit of photodiode. This is for pulsed-light conditions only.

(4) EXTERNAL VIEWING MULTIPLIER (Mv) switch: Provides three steps of signal sensitivity for oscilloscope viewing of pulsed-light signals.

a. OPEN position: Used when direct connection to photodiode with external readout (no load resistor) is desired.

b. X 1 position: Furnishes a direct signal to oscilloscope (across 5k ohms to ground).

c. X10 position: Attenuates output voltage to oscilloscope by 10 (500 ohms to ground).

d. X100 position: Attenuates output voltage to oscilloscope by 100 (50 ohms to ground).

(5) APERTURE MULTIPLIER (Ma) switch: Provides eight steps of attenuation to the viewed light signal, extending dynamic range of instrument optically. Switch positions are marked according to attenuation factor (1, 3, 10, 30, 100, 300, 1000, and 3000). Built-in compensation maintains aperture ratio accuracy when the diffuser disc is fully illuminated by uniform source irradiance and meter readout is employed.

NOTE

Aperture multiplier positions are within 8% accuracy when using external positions of Detector Head; i.e., scope readout. When the Model 580-11A Indicator Unit is used, accuracy is within 1%.

Modes of Operation

With the 580-20A Detector Head, it is possible to operate in several different modes ranging from simultaneous readings on an Indicator Unit and oscilloscope (or other monitoring device) to a simple Indicator Unit readout. The operating modes are as follows (see also Figure 10):

(1) ANODE INT ONLY: The Model 580-11A Indicator Unit can be used to provide bias voltage and signal readout from the Detector Head by setting Detector switches as follows (this is simplest mode of operation):

a. NEG BIAS VOLTAGE: INT

b. ANODE: INT

c. SIGNAL: ANODE

d. APERTURE MULTIPLIER: 1-position (or operator's choice)

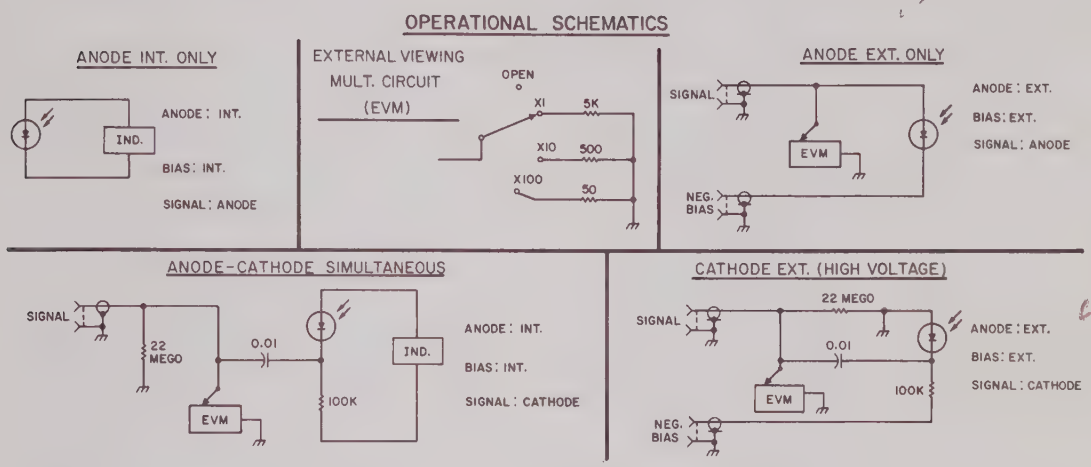


Figure 10. Model 580-20A Series Detector Head Operational Schematics.

(2) ANODE EXT ONLY: In this mode of operation the signal from a source (usually pulsed) can be viewed by an oscilloscope. External bias can be used to provide a larger voltage (1000-volt maximum). Switches are set as follows:

a. NEG BIAS VOLTAGE: EXT
b. ANODE: EXT
c. SIGNAL: ANODE
d. APERTURE MULTIPLIER: 1-position (or operator's choice)
e. EXTERNAL VIEWING MULTIPLIER: operator's choice

The NEG BIAS VOLTAGE can also be set on INT to use Indicator Unit supply. The EXTERNAL VIEWING MULTIPLIER is used as an attenuation device. This places 5k-(X 1), 500-(X 10), and 50-(X 100) ohm resistors in photodiode output circuit, with OPEN position having no resistor. Impedance matching is important in this mode.

NOTE

When using a high-speed traveling-wave oscilloscope, the EXTERNAL VIEWING MULTIPLIER (Mv) switch should be in OPEN position. If observing a very-fast-rising pulse on the oscilloscope, capacity of connecting cable could affect signal by making cable act as a delay line.

(3) ANODE - CATHODE SIMULTANEOUS: Both an Indicator Unit and an oscilloscope can be used simultaneously to monitor output signal (pulse) of Detector Head. Detector bias is provided by Indicator

Unit. Switches are set as follows:

a. NEG BIAS VOLTAGE: INT
b. ANODE: INT
c. SIGNAL: CATHODE
d. APERTURE MULTIPLIER: 1-position (can be varied)
e. EXTERNAL VIEWING MULTIPLIER: operator's choice

Again, the EXTERNAL VIEWING MULTIPLIER is an attenuation device for signal to oscilloscope (but not that to Indicator Unit). The APERTURE MULTIPLIER can be used for Indicator Unit signal (1%), but attenuation of external signal will be only within 8% accuracy.

NOTE

NEG BIAS VOLTAGE above 150 volts cannot be used when Indicator Unit is used as a measuring device. This is when ANODE switch is on INT.

(4) CATHODE EXT (HIGH VOLTAGE): This operation is somewhat similar to that described in (2) above, but has added benefit of isolating oscilloscope from high-voltage bias with a capacitor (0.01μF). Switches are set as follows:

a. NEG BIAS VOLTAGE: EXT
b. ANODE: EXT
c. SIGNAL: CATHODE
d. APERTURE MULTIPLIER: 1-position
e. EXTERNAL VIEWING MULTIPLIER: operator's choice

The NEG BIAS VOLTAGE is still limited to 1000 volts maximum. This operation is for pulsed sources only.

Visual-Alignment Aids

Permanent markings on the handle and on each side nameplate of the Detector Head are visual-alignment aids. The nameplate and handle center lines coincide with the central axis of the Detector optical system. They are used as sighting aids in the vertical and horizontal planes. Additional diverging lines on the handle outline the 14-degree field of view intercepted by the Model 580-32 Hooded Filter Holder. The position of the active detector surface (diffuser disc), from which light source-detector distances are measured, is labeled on the top of the Detector Head. This is the front surface of the Detector Head.

The following specifications pertain to all Model 580-20A Series Detector Heads (Table 2 gives the various spectral ranges as determined by the particular photodiode used):

(1) Max. Peak current (amp): 150 x 10^{-3} with 150-volt internal bias; 1.0 with 1000-volt external bias.
(2) Max. Average current: 10×10^{-6} amp
(3) Effective active area of Head: 2.58 sq in.; 16.6 cm^2
(4) Viewing resistors (ohms): infinity (open), 50 (X 100), 500 (X 10), 5000 (X 1)
(5) Pulse risetime (scope viewing): less than 1 ns with 1 kV (external) bias. Less than 4 ns with internal bias.
(6) Aperture ratios: 1, 1/3, 1/10, 1/30, 1/100, 1/300, 1/1000, 1/3000

(7) Physical characteristics:

a. Length: 6.5 in. (12.5 in. with 3.5 in. dia hood)

b. Width: 5.25 in.

c. Height: 7 in.

d. Weight: 8 lb

Table 2. Model 580-20A Series Detector Head Spectral Ranges.

	Model 580-22A	Model 580-23A	Model 580-25A
Photo Surface	S20	S1	S5
Spectral Range (mμ)	350-800	350-1200	200-750

2.4 MODEL 585-30 SERIES BEAM INPUT OPTICS (Model 580/585 Spectroradiometer)

The Model 585-30 Series Beam Input Optics (Figure 11) consist of a cylinder containing a pair of diffuser discs, an aperture, two light baffles, and a collective lens. The diffuser discs are made of quartz and are mounted together with all surfaces ground except the outside-front surface (the latter is polished to allow easy cleaning of fingerprints and dirt). Since diffuser discs are made of fused quartz, they enable ultraviolet-region operation and can be used throughout the entire spectrum (200 to 1200 mμ). The field of view of the Beam Input Optics is 5°, and the source to be measured must be within this field (±2.5°). Any unwanted energy beyond the 5° field should be compensated out or eliminated. The diffuser discs disperse a beam of light (Figure 12) so that it can be controlled in the optical path of the System.

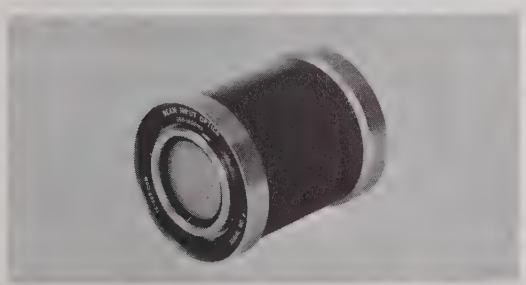


Figure 11. Model 585-30 Series Beam Input Optics.

The two light baffles eliminate stray light from reaching the collective lens. The second light baffle is pre-stressed to compensate for dimensional variations in the mating pieces within the cylinder.

The collective lenses of the Models 585-31 and -32 Beam Input Optics are of glass and quartz, respectively, for the visible - IR and UV regions. The Model 585-30 Series Beam Input Optics are attached to the Model 585-11 Monochromator Housing by a bayonet-type coupling. When using either set of Beam Input Optics the field of view is 5 degrees for full output and calibration accuracy.

NOTE

The Model 585-32 Beam Input Optics, although primarily used in the UV region, can also be calibrated and used in the visible and IR regions.

2.5 MODEL 585-11 MONOCHROMATOR HOUSING (Model 580/585 Spectroradiometer)

General

The Model 585-11 Monochromator Housing (Figure 13) is a cast-aluminum unit (Bausch & Lomb) which receives the grating assembly (see subsection 2.6), entrance slit, and exit slit (see subsection 2.7). The Housing contains the corrector lens, concave mirror, and coupling facilities for

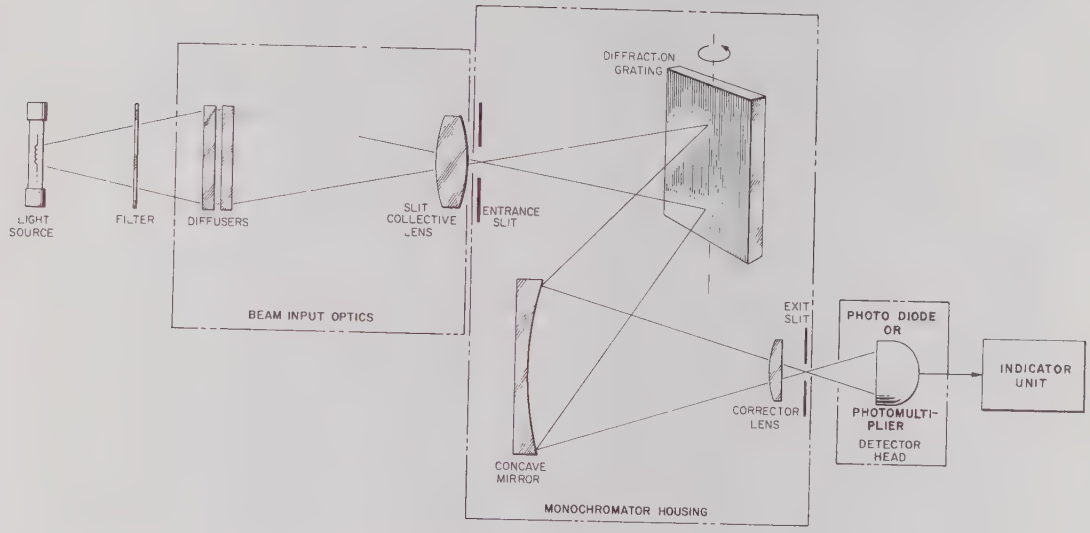


Figure 12. Optical Schematic of a Spectroradiometer.

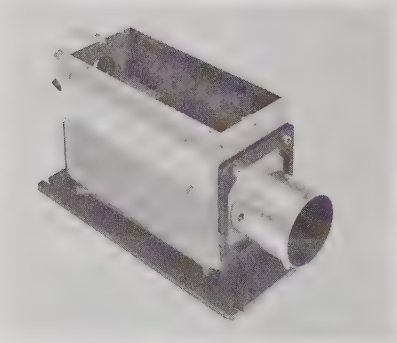


Figure 13. Model 585-11 Monochromator Housing.

connecting appropriate Beam Input Optics and Detector Head. Figure 12 shows schematically the optical configuration of the Monochromator Housing, with grating, slits, and beam input optics attached.

Principles

To explain the principles of the monochromator function it is necessary to treat the housing, grating, and slits as a single package. Light emanating from a source passes through the diffuser system (Beam Input Optics) and is directed by the collective lens into the Monochromator Housing via the entrance slit. Calibration accuracy is obtained when the light incident on the diffuser is imaged on the entrance slit, completely filling the slit area with light. The collective lens of the Beam Input Optics (in front of the monochromator entrance slit) collects the incident light, which is properly matched with the diffuser to create a uniform illuminating bundle inside the Monochromator Housing. This bundle of light is then incident on the plane diffraction grating where it is angularly dispersed according to wavelength. The grating can be

rotated to direct any selected wavelength bundle onto the center of a concave mirror. The mirror collects the light and, with the help of a quartz corrector lens, forms an image of the entrance slit on the exit slit.

The image at the entrance slit is reduced in size at the exit slit by a factor of 0.56. The exit slit, therefore, has a width and height which are 56% of those of the entrance slit. The height is maintained at the correct ratio in the variable slits, but the width should be kept in this same 0.56 relationship for best results. Only the wavelength which strikes the exact center of the concave mirror results in an image which falls precisely on the exit slit. All other wavelengths produce images which are to the right or left of the exit slit. The lateral separation of these images at the exit slit is measured as the dispersion (expressed in millimicrons/millimeter) of the monochromator.

The exit-slit width and the dispersion, in combination, determine the bandpass, or spectral purity, of the system. The optical system is of the noncollimated type to provide an early monochromatic diverging exit beam of f3.5.

As discussed above, the entrance-slit image at the exit slit is 56% of the source size at the entrance slit. It is necessary to multiply the width of the exit slit by 1.78 to obtain the proper width of the entrance slit. Using this ratio, only the selected single wavelength can pass through the system at its full intensity. All other wavelengths will be imaged so that a portion of each is excluded by the exit-slit jaws.

The combination of the grating and a particular pair of slits determines the dispersion in any system. The dispersion values for the slits in relation to the various gratings are stated in Table 3. In the case of variable slits, the 56% relationship of output to input must be kept constant and the dispersion expressed in terms of the exit-slit width as units of millimicrons per millimeter (mμ/mm) for each grating. For example, if one were using a Model 585-22 Grating (visible region) with Model 585-20-24 Variable Slits (subsection 3.4) and the requirement demanded the dispersion to be held at 16 millimicrons, the exit-slit setting would have to be 2.5 millimeters with the entrance-slit setting at 4.47 millimeters.

Table 3. Dispersion Values.

SLITS			GRATINGS		
	Entrance	Exit	Effective Width		
Model No.	Width	Width	Visible 585-22	IR 585-23	UV 585-24
585-20-21	5.36 mm	3.00 mm	20 mμ	40 mμ	10 mμ
585-20-22	2.68 mm	1.50 mm	10 mμ	20 mμ	5 mμ
585-20-23	1.34 mm	0.75 mm	5 mμ	10 mμ	2.5 mμ
585-20-24	Variable	Variable	6.4 mμ/mm	12.8 mμ/mm	3.2 mμ/mm

2.6 MODEL 585-20 SERIES GRATINGS (Model 580/585 Spectroradiometer)

Model 585-20 Series Gratings (Figure 14) are used with the Model 585-11 Monochromator Housing in all Spectroradiometer System configurations. Three different Gratings are available (Table 1); selection is determined by the desired light-range response. The Gratings, when inserted, form the top of the Monochromator Housing.

(TOP VIEW) (BOTTOM VIEW)

Figure 14. Model 585-20 Series Grating.

(Four captive screws on the grating top plate secure the grating assembly to the Monochromator Housing.) Filters are commonly used with these Gratings (refer to subsection 2.11).

CAUTION

The Model 585-11 Monochromator Housing should never be left without a cover (i.e., with grating assembly removed) for even short periods of time because of danger of collecting dust or other foreign material in the housing. When the Monochromator Housing is not in use, the slit openings should be covered by having a cap or mating hardware attached to them. Spare grating assemblies must be kept in their storage boxes. The first-surface aluminized optical elements are very susceptible to permanent damage from atmospheric contaminants or accidental physical contact. Never attempt mechanical cleaning of mirrors or gratings. Blowing away of dust particles is permissible only with prepackaged aerosol cans of dry air. Moisture in the breath may coat optical surfaces.

Internal optical adjustments in the Monochromator Housing and grating assemblies have been made at the factory using specialized fixtures. Disassembly of these units, other than as directed in this manual, should not be attempted.

The Model 585-22 Grating is a 1350-groove-per-millimeter grating covering the visible region from 350 to 800 millimicrons in the first order. It is blazed at 500 millimicrons. The reciprocal linear dispersion is 6.4 millimicrons per millimeter. The smallest scale division for this grating assembly is 5 millimicrons.

The Model 585-23 Grating is a 675-groove-per-millimeter grating covering the infrared region from 700 to 1600 millimicrons in the first order. It is blazed at 900 millimicrons. The reciprocal linear dispersion is 12.8 millimicrons per millimeter. The smallest scale division for this grating assembly is 10 millimicrons.

The Model 585-24 Grating is a 2700-groove-per-millimeter grating covering the ultraviolet region from 180 to 400 millimicrons in the first order. It is blazed at 250 millimicrons. The reciprocal linear dispersion is 3.2 millimicrons per millimeter. The smallest scale division for this grating assembly is 2 millimicrons.

2.7 MODEL 585-20-20 SERIES FIXED SLITS (Model 580/585 Spectroradiometer)

Model 585-20-20 Series Fixed Slits (Figure 15) are used in all Spectroradiometer System configurations. Three groups of Fixed Slits are furnished with each system. Each group contains one "entrance slit" and one "exit slit", precut to furnish the correct dispersion at the desired

Figure 15. Model 585-20-20 Series Fixed Slits.

wavelength. Actual width of the fixed slit in millimeters is engraved on the face of each slit to avoid a mismatch. A detailed explanation of slit function is incorporated in the Model 585-11 Monochromator Housing discussion (subsection 2.5). The Fixed Slits are mounted by two screws to the flat shoulder inside the bayonet-type coupling at the front and back of the Model 585-11 Monochromator Housing.

2.8 MODEL 585-00-11 ADAPTER (Model 580/585 Spectroradiometer)

The Model 585-00-11 Adapter (Figure 16) is utilized for Model 580/585 Spectroradiometer applications only. It consists of a plate for mounting the Model 585-11 Monochromator Housing and a Model 580-20A Series Detector Head on a common base. It may also be used to mount a Model 585-66 High-Sensitivity Detector Head, but not the Model 585-63 High Sensitivity Detector Head (see also subsection 2.9 below and Table 1). The plate utilizes knurled thumbscrews to secure the Monochromator Housing and Detector Head. It has tapped holes to permit tripod mounting (1/4 - 20 thread).

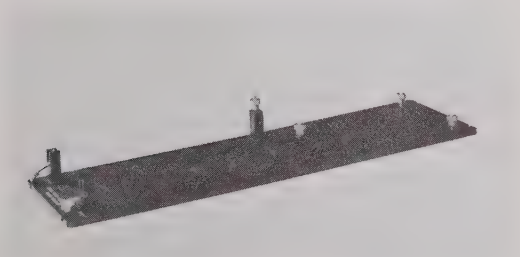


Figure 16. Model 585-00-11 Adapter.

2.9 MODEL 585-00-12 ADAPTER (Model 580/585 Spectroradiometer)

The Model 585-00-12 Adapter (shown in Figure 4) is designed specifically for mounting the Model 585-63 High-Sensitivity Detector Head and Model 585-11 Monochromator Housing on a common base. However, its versatility is such that it can also be used to mount the Model 585-66 High-Sensitivity Detector Head and the Model 580-20 Series Detector Heads used in conventional Model 580/585 Spectroradiometer applications (see Table 1). This Adapter also utilizes knurled thumbscrews to secure the mounted components.

2.10 MODEL 580-00-31 PHOTOMETRIC FILTER (Model 580 Radiometer and Model 580/585 Spectroradiometer Systems)

This Filter (Figure 17) is used in conjunction with a Model 580-25A Detector Head to alter the response of the photodiode to approximate the luminosity (eye response) curve. There are two calibration constants associated with this filter: K3 and K4. Calibration constant K3 is expressed:

$$\frac{\text{Amperes}}{\text{Lumens/ft}^2} \text{ or } \frac{\text{Coulombs}}{\text{Lumens-sec/ft}^2}$$

Figure 17. Model 580-00-31 Photometric Filter.

K4 is expressed:

$$\frac{\text{Volts}}{\text{Lumens/ft}^2}$$

The calibration is made with a 6000°K photometric standard which approximates daylight, and the calibration accuracy is 5% absolute (traceable to NBS).

2.11 MODEL 585-20-10 SERIES FILTERS (Model 580/585 Spectroradiometer)

Four filters can be furnished with each Model 580/585 Spectroradiometer System. Two filters are used in a pair to cover the visible region and single filters to cover the near infrared and ultraviolet. The filter combinations and ranges are stated in Table 4.

These filters (shown in Figure 18) eliminate the higher orders of wavelength set up by the gratings in the Monochromator Housing. For example, the Model 585-20-11 Filter, which is used in the region between 350 and 550 millimicrons, has zero transmission below 295 millimicrons. The higher orders of 550 millimicrons are: 275 millimicrons, 183.5 millimicrons, 137.5 millimicrons, 110 millimicrons, etc., and would be eliminated using the Model 585-20-11 Filter. In optics, the multiples of a wavelength greater than the basic wavelength are not considered because they are not generated by the basic wavelength. In the ultraviolet region all harmonics of any wavelength below 300 millimicrons are not passed because the optics of the system do not transmit below 200 millimicrons. The highest harmonic encountered would be the second harmonic of 300 millimicrons, or 150 millimicrons. However, the photodiode has a negligible response to wavelengths below 155 millimicrons and a filter is not necessary.

Table 4. Filter Combinations and Ranges.

Model No.	Corning No.	Region	Range ($m\mu$)
585-20-11	CS-0-54	Visible	350 to 550
585-20-12	CS-3-69	Visible	550 to 800
585-20-13	CS-2-64	Near IR	700 to 1200
585-20-15	CS-9-54	Ultraviolet	300 to 400

NOTE: No filter used in 200 $m\mu$ to 300 $m\mu$ range (ultrav-violet).

The filters are marked with the RETMA Color Code to show their CS number and serial number. The colors start from the left-hand side of the filter edge and show the CS number as three color bands (e.g., CS-0-54 shows black, green, and yellow). The serial number is the one, two, or three color bands in the middle of the edge. Calibration certificates accompanying each system state the serial number of the filter used during calibration.

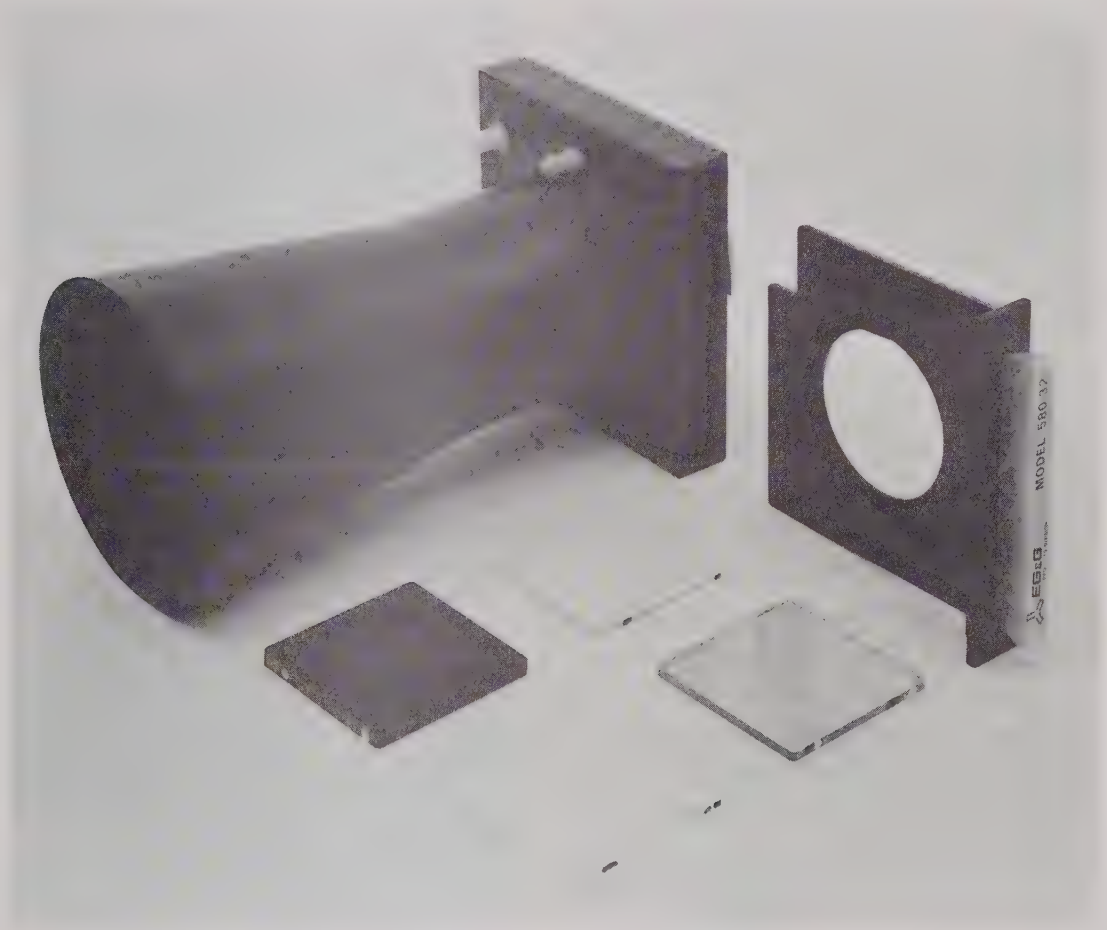


Figure 18. Model 580-32 Hooded Filter Holder with Model 585-20-10 Series Filters.

2.12 MODEL 580-32 HOODED FILTER HOLDER (Model 580 Radiometer and Model 580/585 Spectroradiometer System)

This combination-filter-holder-and-viewing-hood (Figure 18) adds two capabilities to the Radiometer and Spectroradiometer Systems. The filter-holder portion can be used to mount any of the Corning glass filters supplied with the Model 580/585 Spectroradiometer System, or any special narrow-bandpass filters used with Model 580 Radiometer System applications. Two filters, if required, can be inserted into one holder. Round, special filters not exceeding 2.75 inches (70 mm) in diameter and square, special filters not exceeding 2.0 inches (51 mm) in side dimension can be mounted without modifications. Spring clips, permanently fastened to the slide-in filter holder, position and retain the filters.

The viewing-hood portion minimizes the effects of scattered and ambient light when measuring light from specific sources. The cone-shaped hood restricts the field of view to 14 degrees. This is equivalent to a one-foot diameter source at a distance of four feet.

Both portions of the Model 580-32 Hooded Filter Holder have a black matte finish on the interior surfaces to prevent reflected-light problems. A bayonet-type coupling enables the unit to be quickly attached to the various Detector Heads of the Radiometer System and to the Beam Input Optics of the Spectroradiometer System. A shutter-release pin, installed in the filter holder housing, enables remote shutter control without decoupling when the Hooded Filter Holder is directly coupled to a Model 585-60 Series High-Sensitivity Detector Head.

2.13 MODEL 585-60 SERIES HIGH-SENSITIVITY DETECTOR HEADS (Model 580/585 Spectroradiometer)

General

The Model 585-66 and Model 585-63 High-Sensitivity Detector Heads (see Figures 19 and 20) comprise the Model 585-60 Series. These Detector Heads are designed essentially for use with the Model 580/585 Spectroradiometer System, although both may also be calibrated as radiometers, if desired. They permit absolute measurements of low-intensity, pulsed or CW, light signals in the ultraviolet and visible (Model 585-66) and infrared (Model 585-63) regions. Each incorporates a photomultiplier tube to

Figure 19. Model 585-66 High-Sensitivity Detector Head (Model 585-00-60 Power Supply, A Separate System Component, Also Shown to Illustrate Mounting).

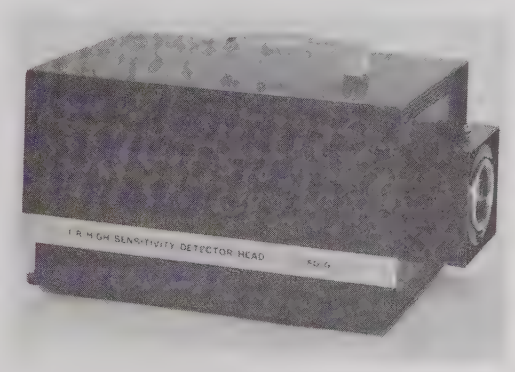


Figure 20. Model 585-63 High Sensitivity Detector Head.

provide approximately five decades of additional system sensitivity over that furnished by a Model 580-20A Series Detector Head (see subsection 1.4 and Figure 7 for additional data on Spectroradiometer System sensitivities).

Both Detector Heads operate from the regulated power supplied by the Model 585-00-60 Power Supply, which is completely interchangeable between the two system configurations although the manner of mounting and connections differ. The Model 585-63

Detector Head also operates in conjunction with the Model 585-00-63 Controller which assures a constant operating temperature. (Further details on these auxiliary components are provided in individual treatments on following pages.)

Mechanical

Consistent with the Model 580/585 Spectroradiometer concept of convenience, the Model 585-60 Series Detector Heads have the quick-disconnect, accurate optical-alignment capability of bayoneting to the Model 585-11 Monochromator Housing (see Figures 3 and 4), ensuring optimum optical coupling throughout the system. In addition, to allow equal ease of use in left-to-right or right-to-left optical setups, the Model 585-00-60 Power Supply is completely reversible in its mating to both the Model 585-66 Detector Head and the Models 585-00-11 and 585-00-12 Adapters.

Optics

The Model 585-60 Series Detector Heads are designed to be coupled to the optical output of the system monochromator with repeated accuracy. Entrance of the light beam into the Detector Head is through a quartz window. Immediately following the entrance window is an automatic safety shutter, designed to prevent possible damage to the photomultiplier tube (PMT) in the event that the operator inadvertently disconnects the Detector Head from the Monochromator Housing without first turning off the PMT power (Section 4). The System has been designed so that the output beam of the monochromator will just fill the active area of the PMT cathode surface, thereby producing maximum utilization of all incident light energy.

Calibration

A Spectroradiometer with a Model 585-60 Series Detector Head is calibrated to its sensitivity versus wavelength, thereby permitting absolute irradiant measurement of both continuous and pulsed light sources. To provide a quick, convenient method of PMT gain calibration, an internal reference source has been included in each Model 585-60 Series Detector Head. Power for this source is derived from the Model 580-11A Indicator Unit.

Radiometer Calibration

The Model 585-60 Series Detector Heads can also be calibrated as radiometers. In this configuration, a diffuser is used on the front of the detector in the same manner as the Model 580-20A Series Detector Heads and the Monochromator Housing is omitted.

External Viewing

For the display of the PMT signal on other than the Indicator Unit meter, a BNC signal connector and a switch (INT/EXT) are provided. (This is a current output which may be terminated in an appropriate impedance.)

Model 585-66 Individual Features

The Model 585-66 High-Sensitivity Detector Head incorporates an S-10 photomultiplier tube and encompasses a spectral range from 200 to 750 millimicrons (UV and visible). This Detector Head mounts directly atop the Model 585-00-60 Power Supply

as shown in Figures 3 and 19. Operating and calibration instructions are given in Sections 4 and 5, respectively.

Model 585-63 Individual Features

The Model 585-63 High-Sensitivity Detector Head incorporates a thermoelectrically cooled S-1 photomultiplier tube and encompasses a spectral range from 350 to 1200 millimicrons (visible and infrared). It operates in conjunction with a Model 585-00-63 Thermoelectric Controller which provides power to the thermoelectronics and maintains the photomultiplier at a constant temperature (within $\pm 0.5^{\circ}C$). This thermoelectric cooling reduces the leakage (dark current) and noise to a level that allows accurate readings to be made of very small light quantities (as low as 10^{-12} watts/cm^2 -mμ or joules/cm^2 -mμ). The 585-00-63 Controller stabilizes the photomultiplier temperature at approx $-20^{\circ}C$ within one hour. The 585-00-60 Power Supply plugs into the Controller instead of the Detector Head in this configuration (see Figure 21). Operating and calibration instructions are given in Sections 4 and 5, respectively.

2.14 MODEL 585-00-60 POWER SUPPLY (Model 580/585 Spectroradiometer)

The Model 585-00-60 Power Supply (Figures 19 and 21) is used with either of the high-sensitivity detector heads. The power supply-detector head combination provides facility for controlling the operating voltage, thereby regulating the photomultiplier gain and preserving calibration of the overall system. The Power Supply operates from a standard 115-volt, 50- to 60-Hz line.

Figure 21. Model 585-00-63 Controller Mounted on Model 585-00-60 Power Supply in Infrared Measurement Configuration.

2.15 MODEL 585-00-63 CONTROLLER (Model 580/585 Spectroradiometer)

The unit consists of a full-wave power supply and solid-state control circuitry. It is capable of delivering 80 watts to 4 thermoelectric cooling elements surrounding the photomultiplier tube. The desired temperature level can be set by adjusting a potentiometer located on the Controller chassis. However, this potentiometer is factory-adjusted to maintain a PMT constant temperature of approximately $-20^{\circ}C$. A red (cooling) indicator lamp is provided on the side of the Controller. When this lamp is lit, it indicates the Controller is cooling; when it cycles on and off, it indicates the minimum temperature has been reached. The Controller and the Detector Head's Power Supply are connected by inserting the Controller into the Power Supply via three "banana plugs." Three 8-foot cables connect the

Controller to the (IR) High-Sensitivity Detector Head. Two are coaxial cables that supply high voltage to the PMT. The third cable carries power and control functions for the thermoelectric-cooling subsystem. The sole panel adjustment for this combination is the voltage-set potentiometer on the Power Supply.

3.1 GENERAL

This section contains a description of each of the accessories for the three (para 1.1) basic systems and an explanation of its principal operational features. Illustrations of each accessory are provided.

NOTE

Keep in mind throughout these instructions that many accessories are common to more than one system.

3.2 MODEL 580-00-11 NARROW-BEAM ADAPTER/LASER ATTENUATOR (Model 580 Radiometer System)

The Narrow-Beam Adapter/Laser Attenuator (Figure 22) is an accessory that can be used with the Model 580 Radiometer

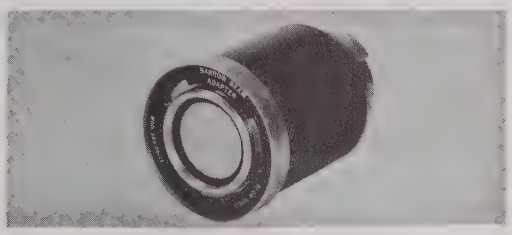


Figure 22. Model 580-00-11 Series Narrow-Beam Adapter/Laser Attenuator.

System and the Series 585-60 High-Sensitivity Detector Heads. It is designed for making measurements of narrow beams of light or coherent laser beams with diameters less than 5/8 inches. It bayonet-couples to the front of the detector head housing. It assures full illumination of the diffuser disc in applications where a light source beam under evaluation would not ordinarily cover the full area. Light accepted from a narrow beam is redistributed over the entire active area of the diffuser disc. This capability validates the detector calibration and permits detector response to remain directionally non-critical. The input beam must be fully contained within a 5/8-inch diameter circle at the center of the diffuser to ensure 100% transfer of the energy to the detector diffuser.

The unit also provides for an additional fixed attenuation of the incident light so that measurements can be made of relatively high laser intensities without overdriving the detector. The attenuation of the accessory is completely calibrated as a function of wavelength to ensure continued absolute measurement capability. The attenuation factor is in terms of

$$\frac{W/cm^2 \text{ out}}{W \text{ in}}$$

This factor when multiplied by the appropriate detector sensitivity in terms of

$$\frac{Amp}{W/cm^2}$$

yields a combined sensitivity in terms of Amp/Watt (or coulombs/joule). The purpose of this unique calibration is to allow the laser to be measured in absolute power or energy terms rather than in the power density and energy density terms of the standard detector calibration.

This accessory can be utilized with most diode and gas lasers. It can also be used with most ruby and neodymium laser systems with peak outputs up to approximately 100 MW.

3.3 MODEL 580-00-12 LASER-BEAM SAMPLER (Model 580 Radiometer)

The Laser-Beam Sampler (Figure 23) is used for measuring, with a minimum amount of interference, narrow beams of high-intensity light such as those produced by ruby and neodymium laser systems. It is used in conjunction with the Narrow-Beam Adapter/Laser Attenuator and permits measurements of peak powers between 100 MW and 10 GW and measurements of integrated energies as high as 10,000 joules. This accessory directs a calibrated percentage of the laser output (≈ 0.3%) onto the Narrow-Beam Adapter diffuser while allowing approximately 80% of the output to be utilized for other experimental studies. An alignment mirror near the input window allows autocollimating of the Laser-Beam Sampler with a light source. Due to a unique design feature, polarization of the light beam will not affect the measurements.. Calibration data (see certificate) provides through-beam transmission and measurement beam attenuation. The Laser-Beam Sampler attaches directly (bayonet coupling) to the Model 580-00-11 Narrow-Beam Adapter/Laser Attenuator.

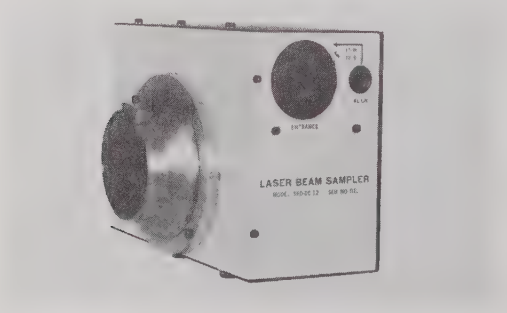


Figure 23. Model 580-00-12 Laser-Beam Sampler.

3.4 MODEL 585-20-24 VARIABLE SLITS (Model 580/585 Spectroradiometer)

Variable Slits (Figure 24) can be used in all Spectroradiometer System configurations as an optional item. A detailed explanation of slit operation is furnished in the discussion on the Model 585-11 Monochromator Housing in subsection 2.5. The Variable Slits are mounted directly to the housing face behind the bayonet-type couplings. Before installing the Variable Slits the bayonet-type couplings must be removed by turning off the two retaining screws. The Variable Slits are then held to the housing face while the bayonet-type couplings are reaffixed.

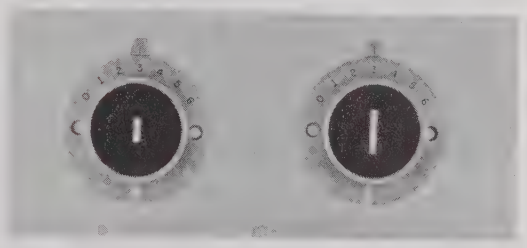


Figure 24. Model 585-20-24 Variable Slits.

3.5 MODEL 585-11-11 WAVELENGTH TRANSDUCER (Model 580/585 Spectroradiometer System)

The Wavelength Transducer (Figure 25) can be used in all Spectroradiometer System configurations. To obtain a direct plot of wavelength versus intensity, an X-Y recorder is used in conjunction with the recorder output (REC OUT) in the Model 580-11A Indicator Unit and the Wavelength Transducer (see Figure 26). The Wavelength Transducer provides a voltage output to drive the X-coordinate of the X-Y recorder

in a linear proportion to the wavelength setting while the Indicator Unit drives the Y-coordinate. Thus, a direct spectrum plot of any light source can be obtained.

The Wavelength Transducer mounts onto the grating on the top of the Model 585-11 Monochromator Housing. After the initial setup (subsection 4.3), utilization of a special adapter ring allows the Wavelength Transducer to be used with all three gratings.

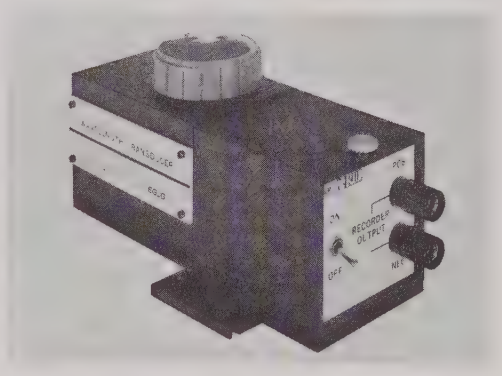


Figure 25. Model 585-11-11 Wavelength Transducer.

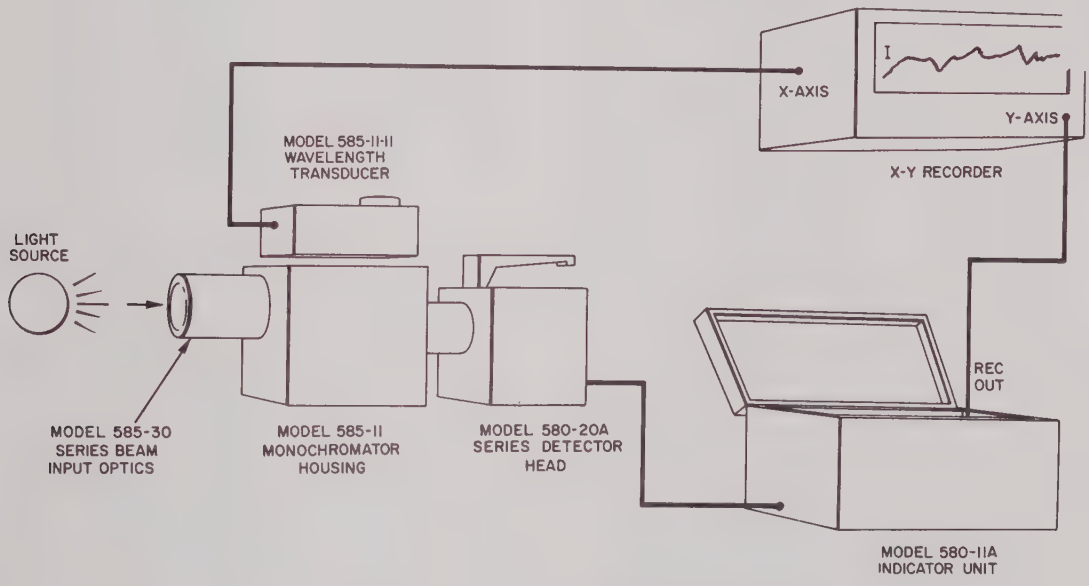


Figure 26. Equipment Setup For a Direct Plot of Wavelength Versus Intensity.

4.1 MODEL 580 RADIOMETER SYSTEM OPERATION

General

The Model 580 Radiometer System uses simplified techniques for measuring pulsed- and steady-light sources. The simplified procedures and inherently stable optical and electronic elements of the Model 580 Radiometer enable consistent repetitive measurements to be taken. The following paragraphs explain the procedure for measuring steady light, a light pulse, or a train of light pulses with the System. The method of using the Radiometer for oscilloscope display of pulsed-light waveshapes is also included.

Basic Operating Setup

The following steps, when completed, compose the basic setup procedure for the Model 580 Radiometer:

a. Connect a Model 580-11A Indicator Unit cable to a 580-20A Series Detector Head (spectral region of interest dictates specific Detector Head as indicated in Table 1 and Figure 7).

CAUTION

Check that Detector Head input diffuser disc (or discs) have been reinstalled if Head previously used in Spectroradiometer System.

b. If a photometric filter is desired for light measurement, connect it to the Detector Head (see subsection 2.10).

c. Connect Model 580-32 Hooded Filter Holder to Detector Head.

d. Check mechanical zero on Measurement Indicating Meter (Figure 8).

e. Connect Indicator Unit power cable to external 117-V, 60-Hz (220-V, 50-Hz) line if battery operation is not desired. Place POWER switch (Indicator Unit) to appropriate position. Allow a two-minute warm-up time to stabilize all circuits.

Premeasurement Adjustments

Set Indicator Unit controls as given in Table 5. Position Model 580-20A Series Detector Head in approximate final alignment for light measurement. Indicator Unit controls should remain in positions specified in Table 5. Place Detector Head controls to positions specified in Table 6.

For preliminary adjustment of the Radiometer System prior to actual current measurements, perform the following steps:

Table 5. Indicator Unit Control Settings.

Control	Position	Remarks/Action
POWER switch	LINE or BATTERY (Operator's choice)	Pilot lamp blinks.
(COMPENSATION) "Function" switch	OFF CURRENT	– –
AMPERE MULTIPLIER switch	$X10^{-6}$	–
INTEGRATE switch	HOLD	*
ZERO SET potentiometer	–	Adjust control for a meter indication of zero using X 3 MULT to exaggerate zero offset (see Note).
CURRENT DAMPING potentiometer	Full CCW	–

*After adjustment of ZERO SET, return INTEGRATE switch to RESET position.

NOTE

Press X3 MULTIPLIER and zero meter with ZERO SET control. With alternate depressing of X3 MULTIPLIER, meter should be set as to have no movement when depression is made. This non-movement point should be the zero line of meter; if this is not the case, mechanical zero of meter is off. Simply turn off power and adjust meter zero screw (front of meter) with a screwdriver. Turn on power again and repeat foregoing procedure. Indicator Unit internal circuitry is now balanced at a zero point.

a. Approximately position Detector Head to accept same ambient light that will be viewed during actual measurement.

b. Establish scale of measurement by momentarily energizing light source. Note ambient current reading on this scale.

c. Select proper COMPENSATION RANGE position (Indicator Unit) to zero meter reading.

d. Adjust COMPENSATION VERNIER for zero meter reading on this setting of AMPERE MULTIPLIER switch.

NOTE

Ambient light conditions can vary and proper compensation should be verified for careful measurements. Always recheck after changing Detector Head aperture position (see also special notes on apertures in subsequent subsection).

Table 6. Detector Head Control Settings.

Control	Position	Remarks/Action
NEG BIAS VOLTAGE switch	INT	Detector Head is energized by Indicator Unit.
EXTERNAL VIEWING MULTIPLIER switch	Optional	(Used for external instrument readout only.)
ANODE switch	INT	Enables Indicator Unit to monitor output current.
APERTURE MULTIPLIER switch	1	(Or lowest position for on-scale meter reading.)
SIGNAL switch	ANODE	Signal output from anode of photodiode.

For preliminary adjustment of the Radiometer System prior to actual charge measurements, perform the following steps:

a. Approximately position Detector Head to accept same ambient light that will be viewed during actual measurement.

b. Repeat Table 5 control settings.

c. Set "Function" switch for charge measurement. Select scale of measurement by pulsing light source to be measured.

d. Place INTEGRATE switch from (normal) RESET to INTEGRATE position. Meter will indicate amount of integrated ambient light.

e. Select appropriate position of COMPENSATION RANGE switch to minimize rate of meter movement.

f. Adjust COMPENSATION VERNIER potentiometer to stop meter movement for selected setting of COULOMB MULTIPLIER switch. Verify compensation adjustment by switching to RESET and then back into INTEGRATE position of INTEGRATE switch several times.

g. Readjust COMPENSATION VERNIER potentiometer, if necessary, to hold constant meter reading.

NOTE

Regularly check compensation because ambient light can vary. Readjust compensation after changing aperture setting (see also subsection 2.3).

Detector Head Positioning

The sighting aids incorporated in the Model 580-20A Series Detector Heads provide a simple positioning method for Detector Head and light source. Sight alignment accuracy with the light source is better than one degree when using the "centerline" guide markings on the handle and on each side of the Detector Head. The field-of-view guide markings on the handle show that the light source under evaluation is fully seen by the Detector Head. Because the viewing hood and diffuser disc function to make alignment non-critical, the accuracy of a careful visual positioning is sufficient for reliable light measurements with the instrument.

The Detector Head to light source distance is measured from the plane of the diffuser disc. This plane is marked on the top of the Detector Head and coincides with the front surface of the Detector Head. The Detector Head to light source distance will vary with the types of measurements, source power, and geometry. For absolute radiometric or photometric measurements, the "minimum-inverse-square distance" should be used. This is generally approximated by use of a minimum distance ten times that of the largest source dimension. Final positioning of the Detector Head then requires only that the light source be aligned as follows:

(1) Centered and fully included in Detector Head field of view.

(2) At a known distance greater than minimum-inverse-square distance for absolute measurements, or consistently reproducible for relative measurements.

Measurement Procedures

For final measurement of average power of steady light sources, utilizing meter readout, proceed as follows:

a. Align Detector Head as already described.

b. Set controls on Indicator Unit for CURRENT measurement.

c. Adjust APERTURE MULTIPLIER and AMPERE MULTIPLIER settings, as necessary, to obtain maximum meter indication.

d. Energize light source.

e. Record final meter reading and settings of AMPERE MULTIPLIER and APERTURE MULTIPLIER switches. Final current in amperes is proportional to irradiance viewed by Detector Head.

NOTE

A sample calculation of measurement of average power of a steady light source is supplied at the end of this Radiometer System operating subsection.

For final measurement of integrated energy of pulsed light sources, utilizing meter readout, proceed as follows:

a. Align Detector Head as already described.

b. Set controls on Indicator Unit for CHARGE measurement.

c. (Adjust ZERO SET control only in CURRENT side, as described in Table 5.) Adjust COMPENSATION control to stop up-scale movement in INTEGRATE position. If light source cannot be triggered or scheduled, the INTEGRATE switch must be advanced to INTEGRATE prior to commencement of light pulse (return switch to HOLD position when light pulse has ceased).

NOTE

Proper measurement of a random light source (event) requires operating familiarity.

d. Adjust APERTURE MULTIPLIER and COULOMB MULTIPLIER for maximum meter indication through successive measurements. Record final meter indication and settings of COULOMB MULTIPLIER and APERTURE MULTIPLIER switches. Final meter indication in coulombs is proportional to total integrated irradiant energy in pulse as viewed by Detector Head.

e. If the light source can be triggered, the appropriate SYNC contacts, N. O. or N. C., are used to trigger it. Using this procedure, light source is initiated by advancing INTEGRATE switch from RESET through INTEGRATE position to HOLD position in a firm, fluid movement. Terminal jacks are provided for the synchronization signal connection. Adjust APERTURE MULTIPLIER and COULOMB MULTIPLIER for maximum meter reading through successive measurements. Record final meter indication and settings of COULOMB MULTIPLIER and APERTURE MULTIPLIER switches.

f. Single-pulse measurement procedures also apply to a burst (short) of pulses. Bursts can be measured as random events or synchronized events triggered by the INTEGRATE switch. Measurement in this case represents total value of integrated irradiant energy in burst as viewed by Detector Head. Any ambient or leakage that is not balanced out will cause an error in readings; see para. 2.2(12).

Measurement capabilities of the Model 580-20A Series Detector Heads provide for oscilloscope display of repetitive and transient voltage or current signals. For oscilloscope viewing, the SIGNAL connector on the Detector Head is connected by a coaxial cable to the vertical deflection plates of a suitable fast-rise, wide-band oscilloscope.

With the ANODE switch in the EXT position, voltage proportional to the light event seen by the Detector Head is displayed on the oscilloscope. The position of the EXTERNAL VIEWING MULTIPLIER switch provides three levels of signal amplitude. If it is desired to use the Indicator Unit simultaneously with the oscilloscope, set the SIGNAL switch to CATHODE and the ANODE switch to INT. For oscilloscope viewing, the Model 580-11A Indicator Unit or an external power supply can be used to bias the Detector Head.

CAUTION

Do not apply more than 150V to the bias when using the Indicator Unit. There is also a 150-ma current capability limit on the Indicator Unit power supply. If this limit is exceeded, error and distortion will be introduced by flattening of the pulse and elimination of the peak. If in doubt, calculate the current by dividing the pulse width into the charge in coulombs. If the value exceeds 150 ma, use the apertures to attenuate it.

The INTEGRATE switch and SYNC contacts can be used to initiate a pulsed-light event. Voltage measurements and pulse-shape characteristics are made directly from the oscilloscope trace.

Apertures When Using Oscilloscope

The Model 580-20A Series Detector Heads are set up with a variable-aperture wheel that allows the full photodiode to look at various portions of the input diffuser, from full diffuser to 1/3000 of the diffuser (explained in subsection 2.3, Optics).

When using the 580-20A Series Detector Heads with an oscilloscope, the trimming potentiometers are not in effect and the apertures have their normal mechanical ratios. With a simple technique it is possible to determine the mechanical error in the apertures to make more accurate readings with an oscilloscope. The step procedure is as follows:

a. Connect 580-20A Series Detector Head to Model 580-11A Indicator Unit.
b. Set Indicator Unit controls as follows: RANGE COMPENSATION to OFF; INTEGRATE to HOLD; AMPERE MULTIPLIER to X 10^{-6}; CURRENT-CHARGE to CURRENT; POWER to LINE or BATTERY.
c. Zero unit, also using X3 MULTIPLIER to exaggerate zero offset.
d. Set Detector Head controls as follows: ANODE to INT; NEG BIAS VOLTAGE to INT; SIGNAL to ANODE; APERTURE MULTIPLIER to 1.
e. Switch Indicator Unit controls as follows: CURRENT-CHARGE to CHARGE; COULOMB MULTIPLIER to X 10^{-8}; INTEGRATE to RESET.
f. The meter should be reading less than 1 on scale. If not, reduce amount of light that Detector is

seeing. This can be done by simply aiming or partially covering Detector Head.

g. Put INTEGRATE switch in INTEGRATE position and allow meter to travel to approx. 8 on the scale before pushing the INTEGRATE switch into HOLD.

h. Copy down value on meter. Switch down through aperture positions 3, 10, 30, etc., and copy down values on meter in each aperture position while INTEGRATE switch is kept in HOLD position. Deviations in meter readings are electrical corrections that were made at summing junction of Indicator Unit by trim potentiometers.

i. Take 1-aperture position value and find difference reading (plus or minus) from each of other aperture positions. Percent mechanical difference is 1-aperture reading divided into difference between 1-aperture reading and any other aperture reading times 100. That is

$$\% \text{ Error} = \frac{(R_{1ap} - R_{xap})\ 100}{R_{1ap}}$$

Example:

The 1-aperture charge reading is 8.02 x 10^{-8} Coul.

The 10-aperture charge reading is 7.49 x 10^{-8} Coul.

$$\% \text{ Error} = \frac{(8.02 - 7.49)\ 100}{8.02} = 6.6\%$$

TYPICAL EXAMPLE, RADIOMETER MEASUREMENT

What is the average power of a light source whose output at 500 mμ gives a meter reading of 4.0 x 10^{-7} ampere (A)? System sensitivity at 500 mμ is 1.2 x 10^{-2} A/W/cm^2. Wavelength of source 500 mμ is set by narrow-bandpass filter whose transmission at 500 mμ is 85%. Aperture multiplier is set at 10-position. Source output is calculated as follows:

$$P = \frac{4.0 \times 10^{-7} \times 10}{1.2 \times 10^{-2} \times 0.85}$$

$$= 3.92 \times 10^{-4} \text{ W/cm}^2$$

4.2 MODEL 580/585 SPECTRORADIOMETER OPERATION

General

The following instructions explain the operational procedures necessary for proper operation of the Model 580/585 Spectroradiometer System when using the Model 580-20A Series Detector Heads.

NOTE

The apertures discussed above are not used in measurements with the Spectroradiometer System since the beam from the Monochromator is small and the diffuser is not used. The beam falls directly onto the photodiode surface. The apertures could do nothing more than eliminate an undetermined amount of light.

Basic Operating Set-Up

Before using the Spectroradiometer System, the spectrum to be measured must be determined. This will dictate the selection of components used in the system. The following step-by-step procedure, beginning at the light source end of the system, should be adhered to to obtain satisfactory operating results:

a. Select Model 585-20-10 Series Filter for range to be measured and install it in Model 580-32 Hooded Filter Holder (see Table 4). The hood portion of the holder may be removed.

b. Connect Filter Holder portion to appropriate Model 585-30 Series Beam Input Optics (see subsection 2.4).

c. Before attaching Beam Input Optics to Monochromator Housing, select and attach appropriate Model 585-20-20 Series Fixed or Variable Slits, determined by amount of dispersion desired in output beam (see Table 3 and subsections 2.7 and 3.4). If it is desirable to use Variable Slits, proper ratios and openings must be set.

NOTE

Spectroradiometer Systems are calibrated at factory using Model 585-20-22 Fixed Slits (entrance width of 2.68 mm and exit width of 1.50 mm) for both visible and IR ranges. For UV range, Model 585-20-21 Fixed Slits (entrance width of 5.36 mm and exit width of 3.00 mm) are used. These are the standard grating-slit combinations, unless otherwise specified in ordering a System. If other slits are used, calibration accuracy must be ascertained prior to use (Section 5). Bandwidth is not considered in the calculation of output, but is required in determining the steps necessary to fully evaluate a source.

d. Install appropriate Model 585-20 Series Grating into Monochromator Housing. Grating selects spectral range to be presented to photodiode in Detector Head (subsection 2.6). Adjust grating control for proper wavelength.

CAUTION

The diffuser disc(s) of a Model 580-20A Series Detector Head must always be removed before attaching Detector Head to Monochromator Housing. A tool is provided for removal of the glass retaining ring. In the Model 580-25A Detector Head, there are two separate pieces of quartz glass used as the diffuser. Be careful when removing them to prevent breakage.

e. Connect Detector Head (see also Figure 7) to Monochromator Housing. Set APERTURE MULTIPLIER switch to 1 position.

f. Attach all components to Model 585-00-11 or -12 Adapter.

g. Connect Model 580-11A Indicator Unit cable to Detector Head. Operating controls for Indicator Unit are explained in subsection 2.2.

h. If desired, the Model 585-11-11 Wavelength Transducer can be attached to top of grating (see subsection 4.3) to give a 0- to 10-mV output from beginning to end of wavelength dial.

Operating Information

Each Spectroradiometer System should be tailored to measure a specific group of wavelengths to obtain proper analysis of the source. The inclusion of detailed instructions for every type of measurement technique is not possible; however, periodic application notes (Section 7) will include techniques for most types of measurements. (The examples provided concerning use of the System with High-Sensitivity Detector Heads are also useful in illustrating general approaches to problems, as is the sample measurement at the end of this subsection.)

NOTE

A sample calculation of a representative measurement of a steady light source is supplied at the end of this Spectroradiometer System operating subsection.

For general purposes, the procedure for assembling a System, as stated in the previous paragraphs, is adequate; however, the information in the following two paragraphs should be noted by the user.

The Detector Head photo surfaces exhibit certain basic characteristics. The S20 (Table 1) surface has the highest gain and broadest coverage of the visible spectrum (3500-8000Å). The S5 response from 2000 to 7500Å can suffer from scattering effects in the UV caused by the UV grating. This problem develops when the energy between 3000 and 8000Å is much greater than the energy below 3000Å. The 0.3% scattering of the UV Grating that develops is an appreciable amount of the energy being received by the photo surface at the lower wavelengths. This problem does not become serious until the 2800Å region is reached; consequently, filters must be utilized in this region. A very-sharp-cut-off filter can be devised by using two pieces of ordinary slide glass (Corning Glass No. 7052). The transmission of the double-slide glass is approximately 1% at 2940Å and 85% from 3700Å up. This device will filter the UV range of interest, leaving the scattered energy so that it can be measured and subtracted from the total readings. This will provide the actual energy reading between the range of 2000 and 2900Å. The value of this scattered energy should be established at 2200 and 2400Å. The average of the two values divided by 0.85 should be subtracted from the readings taken between 2000 and 2900Å.

The S5 and S20 surfaces display the least amount of leakage (dark current). The S1 surface displays the largest amount of

leakage, which requires the use of compensation on the lower current scales.

The light source in order to be measured must be set up with a $\pm 2.5^{o}$ cone working from the center of the first diffuser in the Beam Input Optics. The normal rule (for getting absolute readings) of keeping the distance from this diffuser to the source ten times the maximum source diameter also applies in order to have the source appear as a point. The first diffuser at the Beam Input Optics is always the System reference point.

TYPICAL EXAMPLE, SPECTRORADIOMETER MEASUREMENT

What is the average power of a light source whose output at 500 mμ gives a meter reading of 4.0×10^{-7} ampere (A)? System sensitivity at 500 mμ is 1.0×10^{-2} A/W/cm^2 -mμ. (APERTURE MULTIPLIER is set on No. 1 position;* wavelength is set on grating at 500 mμ.) Source output is calculated as follows:

$$P = \frac{4.0 \times 10^{-7}}{1.0 \times 10^{-2}} = 4.0 \times 10^{-5} \text{W/cm}^2\text{-m}\mu$$

*Aperture setting is always at No. 1 position in all Spectroradiometer System measurements.

4.3 MODEL 585-11-11 WAVELENGTH TRANSDUCER

General

The following text explains the installation and alignment procedures for the Model 585-11-11 Wavelength Transducer (Figure 25).

Basic Operating Set-Up

Perform the following procedures step-by-step.

a. Remove plastic knob from monochromator grating assembly and attach knob to Wavelength Transducer.

b. Attach solid aluminum knob to grating assembly.

c. Remove two rear captive hold-down screws on grating assembly. Replace these screws with two long thumbscrews provided.

d. Set Monochromator to lowest wavelength setting (Ultraviolet range: 200 millimicrons; visible range: 350 millimicrons; infrared range: 0.7 microns).

e. Place outer knob and spring assembly over solid knob on grating assembly. Do not tighten setscrews.

f. Rotate outer knob assembly until setscrew (aligned with drive pin hole on top surface of outer knob assembly) is aligned with bench mark on grating assembly. The second setscrew in outer knob assembly should now be approximately one-third upscale on wavelength markings.

g. Set Wavelength Transducer in place and tighten thumbscrews.

NOTE

Drive pins in knob assembly are not symmetric. If not

installed properly, Wavelength Transducer will not set squarely on Monochromator. In this event, remove the Wavelength Transducer and turn plastic knob until large gear and drive-pin assembly rotate 180°. Reinstall Wavelength Transducer.

h. Check that power switch is in OFF position. Remove battery access cover of Wavelength Transducer.

i. Connect an ohmmeter (1-ohm range) between negative output terminal and center terminal post (Figure 27) on rear edge of gear plate.

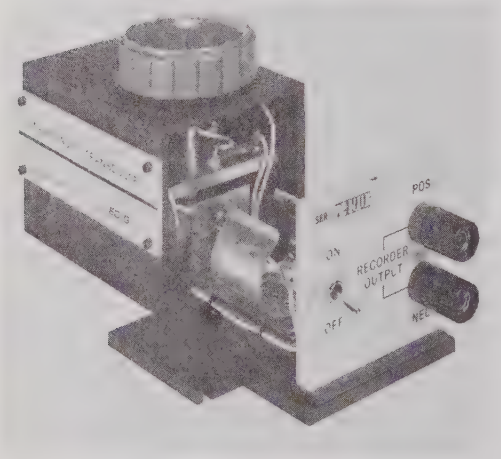


Figure 27. Ohmmeter Connection.

j. Rotate control knob slowly and note lowest resistance reading.

k. Set Monochromator wavelength dial to lowest wavelength for that particular Grating (step d above). (Refer to alignment illustration, Figure 28.)

l. Holding wavelength dial in this position, rotate control knob until ohmmeter is at lowest reading (step j above).

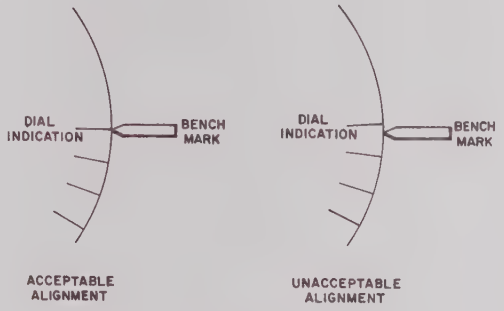


Figure 28. Wavelength Transducer Alignment.

m. Tighten setscrew in outer knob assembly.

n. Rotate control knob and tighten second setscrew in outer knob assembly.

o. Recheck correlation between lowest resistance reading and lowest wavelength setting.

NOTE

Procedures in steps j. through o. must be completed with utmost precision. Any deviation between lowest wavelength setting and lowest resistance reading will result in a deviation between actual wavelength and indicated wavelength.

4.4 MODEL 580/585 SPECTRORADIOMETER SYSTEM (Model 585-60 Series High-Sensitivity Detector Heads, Figures 19, 20, 29, 30)

General

Operation of a Model 580/585 Spectroradiometer System using a Model 585-60

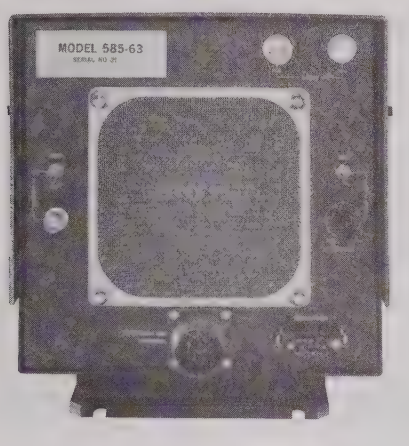


Figure 29. Model 585-63 Detector Head (Showing Controls).

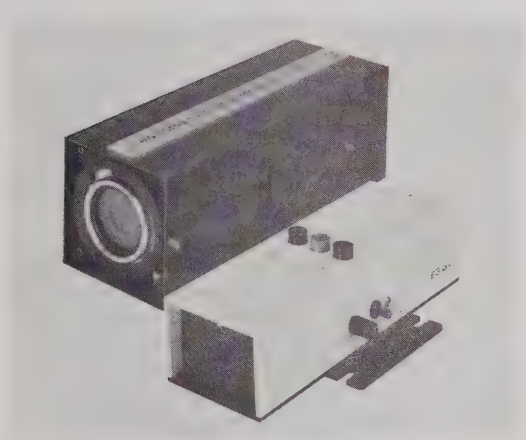


Figure 30. Model 585-66 Detector Head (Uncoupled From Power Supply).

Series Detector Head is generally similar to operation using a Model 580-20A Series Detector Head. For a complete understanding of the 585-60 Series operation, the entire operating procedure is detailed here (the procedure is general enough to apply to use of these detectors as either radiometers or spectroradiometers).

Basic Operating Setup (Figure 6)

a. (Refer to Figure 3 or Figure 4, depending on whether a Model 580-66 or Model 580-63 Detector Head is to be used in the setup.) Then, referring to subsection 2.13 as necessary, connect up pertinent Detector Head - Power Supply - Controller combination. Procedures are obvious. Orient Power Supply (Model 585-66 configuration only) for left-to-right or right-to-left operation as required (the two outside receptacles on the Power Supply are common to allow it to be connected in either direction). In either configuration, Power Supply is locked to its mating component with slide clip fasteners.

b. Select and install appropriate entrance and exit slits on Model 585-11 Monochromator Housing (see subsections 2.5, 2.6, 2.7).

c. Bayonet-couple Detector Head (and Power Supply if Model 585-66 used) to Model 585-11 Monochromator Housing.

d. Insert proper grating for spectral region of interest into Monochromator Housing.

NOTE

Specific model numbers of Detector Heads, Monochromator Gratings, Beam Input Optics, etc., are determined by spectral region of interest (see subsections 2.4, 2.5, 2.6, Table 1, and Figure 7).

e. Attach Monochromator, Detector Head (and Power Supply, if 585-66)

to Model 585-00-11 or 585-00-12 Adapter.

f. Select and bayonet proper Model 585-30 Beam Input Optics to front end of Monochromator Housing (subsection 2.4).

g. Attach Model 580-32 Hooded Filter Holder in front of Beam Input Optics and insert proper Model 585-20-10 Series Filter (Table 4) into Holder.

h. Connect Indicator Signal cable to 14-pin connector at rear of Detector Head (either 585-66 or 585-63).

i. If used, connect Controller cable to 10-pin connector at rear of Detector Head (585-63 only). Similarly, if used, connect both coaxial cables from Controller to Detector Head (585-63 only) observing correct polarity.

j. Set power switches to OFF on both Power Supply and Indicator Unit and plug in line cables.

k. Set controls as indicated in Table 7. The controls are to be operated for each of the three basic measurements, these consisting of: steady-light source, pulsed-light source, and oscilloscope display of peak power, pulse width, pulse shape.

NOTE

The first procedure which follows describes adjustment of the internal lamp gain.

Table 7. Control Settings.

Control	Position
INDICATOR UNIT	
AMPERE MULTIPLIER	X 10^{-6}
COULOMB MULTIPLIER	X 10^{-7} or X 10^{-8}
CURRENT – CHARGE	CURRENT
COMPENSATION	OFF (VERNIER CCW)
INTEGRATE Switch	HOLD
CURRENT DAMPING	CCW
POWER	LINE or BATTERY
DETECTOR HEAD	
Shutter (see note below)	Closed
CALIB Switch	OFF
CALIB ADJUST	Mid-Range Mark
SIGNAL	INT
POWER SUPPLY	
VOLTAGE	MIN (Full CCW)
POWER	OFF

NOTE

The Detector Head shutter can be opened by lifting chrome plunger located in front of carrying handle. Depressing red button on face of Detector Head closes shutter (Figure 31).

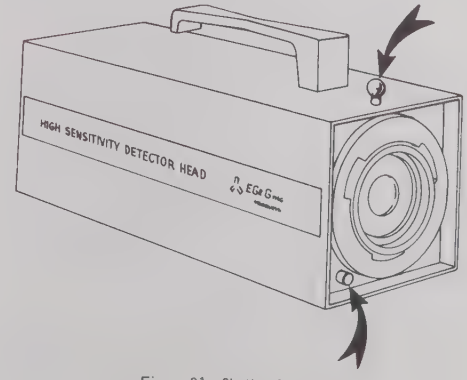


Figure 31. Shutter Controls.

l. Wait one minute, press X3 MULTIPLIER (if applicable), and zero meter with ZERO SET control. With alternate depressing of X3 MULTIPLIER, meter should be set as to have no movement when depression is made. This non-movement point should be the zero line of meter; if this is not the case, mechanical zero of meter is off. Simply turn off power and adjust meter zero screw (front of meter) with a screwdriver. Repeat from step k on. Indicator Unit internal circuitry is now balanced at a zero point.

m. Set Power Supply POWER switch to ON.

NOTE

In the situation where the Model 585-63 High-Sensitivity Detector Head is cooled, the Model 585-00-63 Controller should be turned on one hour prior to taking measurements to allow for stabilization of the cooling cycle.

Internal Gain Adjustment and Compensation Procedures

After a two-minute warm-up, place Detector Head CALIB switch ON. Place Indicator Unit AMPERE MULTIPLIER switch to X 10^{-7} and INTEGRATE switch to RESET.

Set the VOLTAGE control on the Power Supply to give a full-scale reading on X 10^{-7} scale on the Indicator Unit. It might be convenient to make any fine adjustments of this voltage by using the ADJUST knob under the CALIB switch on the Detector Head. This now sets the gain of the photomultiplier to the same value as it was when the System was calibrated.

Turn off the CALIB switch. Switch the Indicator Unit AMPERE MULTIPLIER switch down through the scales until there is a reading on the meter. This reading of leakage, which is approximately three decades lower than the calibration (gain) setting, will obviously have no measurable effect on this setting. Therefore, it can be considered as part of the ambient light condition.

The next step is to balance out the combined leakage and ambient light on the scale on which measurements are to be taken. There are notes of CAUTION to be observed at this point. When using the detector as a Radiometer for broadband light or laser measurements, the level of light the detector is subjected to should not be high enough to saturate the photomultiplier. Therefore, before the shutter is opened, the ambient level should be decreased to a value somewhere near the source to be measured. When in the Spectroradiometer configuration, the problem is not as critical since there is only one wavelength of light available to the photomultiplier; however, the ambient level should be lowered. The Radiometer System is compensated by opening the shutter with the Indicator Unit on X 10^{-7} scale and the source to be measured turned off. Then simply find the scale on

which a reading is present and put the COMPENSATION on LOW (switch to MED or HIGH if necessary) and turn the VERNIER clockwise until there is a zero reading on the meter.

In the case of a pulse source (CHARGE switch position), a final check of the compensation is made in the INTEGRATE position. The needle movement is stopped in the INTEGRATE position by the COMPENSATION VERNIER; then the INTEGRATE switch is moved into RESET, then back into INTEGRATE, where there should be no needle movement. Readjust if necessary.

When making measurements with a Spectroradiometer, the amount of ambient light will change with wavelength; and if there is a reading of ambient light on the scale where the source is measured, then the ambient must be balanced at each wavelength. If the reading is only the leakage of the photomultiplier, then this value can be balanced out at any wavelength and checked occasionally.

The ambient light and photomultiplier leakage are balanced out, and the source is now measured in the conventional manner with the shutter open.

NOTE

The gain adjustment procedure should be repeated at 15-minute intervals to ensure the highest degree of accuracy in precision light measurements. When setting the gain point, it is helpful to consider VOLTAGE and CALIB ADJUST controls as a coarse and fine control respectively.

CAUTION

Turn ambient COMPENSATION controls OFF before adjustment.

Measuring Spectral Irradiance of Steady Source

After the basic operating setup and internal gain adjustments, the 580/585 Spectroradiometer System is ready to perform precision light measurements. The following steps outline the procedure for measuring the average spectral irradiance of a steady light or a continuous train of uniform pulses. Set controls as stated in Table 8, and perform the following steps:

Table 8. Control Settings.

Control	Position
INDICATOR UNIT	
AMPERE MULTIPLIER	X 10^{-6}
COULOMB MULTIPLIER	X 10^{-7}
CURRENT – CHARGE	CURRENT
COMPENSATION	OFF
INTEGRATE Switch	RESET
CURRENT DAMPING	CCW*
POWER	LINE
DETECTOR HEAD	
Shutter	Closed
CALIB Switch	OFF
CALIB ADJUST	As Required
SIGNAL	INT
POWER SUPPLY	
VOLTAGE	As Required
POWER	ON

*Readjust if source is unsteady, or if measuring average value of a pulsing source.

a. Set Monochromator to desired wavelength. Open Detector Head shutter and increase Indicator Unit sensitivity until a meter indication is obtained (i.e., adjust AMPERE MULTIPLIER to 10^{-7}, 10^{-8}, etc.). Block light source to be measured without disturbing other ambient light conditions.

b. Using RANGE and VERNIER controls of COMPENSATION on Indicator Unit, adjust for a meter indication of zero. Unblock light source to be measured, and record meter indication. (With ambient conditions compensated it may be necessary to increase Indicator Unit sensitivity to ensure sufficient up-scale meter indication.)

TYPICAL EXAMPLE

What is the average power of a light source whose output at 800 mμ gives a meter reading of 4.3×10^{-6} ampere (A)? System sensitivity at 800 mμ is 25 A/W/cm^2 -mμ. Each System is provided with a calibration curve of sensitivity vs wavelength.

I_m = current measured on meter (A)

R_λ = System sensitivity at wavelength λ in A/W/cm^2 -mμ

$$H_{800} = \frac{I_m}{R_{800}} = \frac{4.3 \times 10^{-6}\ A}{25\ A/W/cm^2\ -m\mu}$$

$$= 1.72 \times 10^{-7}\ W/cm^2\ -m\mu$$

c. Recorded meter indication is current being generated by photomultiplier due to light source to be measured. This number, divided by system sensitivity at wavelength of Monochromator setting (system calibration curve), is average spectral irradiant power. Repeat measurement at each wavelength of interest and repeat compensation.

Measuring Integrated Spectral Irradiant Energy of Pulsed Source

Following the basic operating setup and internal gain adjustment, the 580/585 Spectroradiometer System is ready to perform precision light measurements. The following steps outline the procedure for measuring the integrated spectral irradiant energy of a pulsed light source. Set controls as stated in Table 8, except place CURRENT-CHARGE on CHARGE.

a. Set Monochromator to desired wavelength. Open Detector Head shutter and check that INTEGRATE switch is in RESET position.

b. Adjust RANGE and VERNIER controls of COMPENSATION so that meter is on zero. Set INTEGRATE switch to INTEGRATE position and use COMPENSATION controls to stop meter needle drift. (This need not be an indication of zero, but rather no movement of meter needle; see also foregoing Gain Adjustment and Compensation Procedure subsection.) Return

INTEGRATE switch to RESET position. Repeat procedure, if necessary, so that meter indication stays at zero with no drift. Leave switch in RESET position.

c. Connect sync input of flash source to N. O. or N. C. SYNC contacts on Indicator Unit, as required. (Omit this step for non-triggerable flash sources.)

d. Trigger flash-event by moving INTEGRATE switch smoothly from RESET through INTEGRATE and into HOLD position. For accurate, precise, repeatable readings, it is necessary that INTEGRATE switch be operated smoothly. If source cannot be triggered, place switch at INTEGRATE prior to pulsing source, then into HOLD after pulsed event.

NOTE

The time it takes to say "RESET / INTEGRATE/ HOLD" is a handy rule of thumb to indicate speed with which the switch should be operated through its respective positions. Do not "flick" switch from position to position, as this will give rise to inaccurate indications.

e. Record meter indication, which is charge in coulombs (ampere-seconds) generated by source. Meter indication is current output of photomultiplier integrated over period of time of flash pulse. This number, divided by system sensitivity at wavelength of Monochromator setting (system calibration curves), is integrated spectral irradiant energy contained in flash event at that particular wavelength. Repeat measurement at each wavelength of interest.

NOTE

Ambient compensation will change with wavelength.

TYPICAL EXAMPLE

What is the integrated spectral irradiant energy of a light source at 800 mμ whose output gives a meter reading of 1×10^{-9} coulomb? System sensitivity at 800 mμ is 25 coulombs/joule/cm^2 -mμ.

Q_m = charge measured on meter in coulombs (C)

R_λ = System sensitivity at wavelength λ in coulombs/joule/cm^2 -mμ

$$E_{800} = \frac{Q_m}{R_{800}} = \frac{1 \times 10^{-9}\ C}{25\ C/joule/cm^2\text{-m}\mu}$$

$$= 4.0 \times 10^{-11}\ joule/cm^2\text{-m}\mu$$

f. In pulse energy measurements there exists a peak anode current above which the response is not linearly related to the input. (In actual practice the maximum peak-current capabilities are 1 milliampere for the Model 585-66 Detec-

tor Head and 10 milliamperes for the Model 585-63 Detector Head.) Charge is a function of both time and current, in which a decrease in time entails an increase in peak current for a given charge. It can be seen that for any given charge there must exist a pulse width below which nonlinearities will be introduced in the measurement, due simply to state-of-the-art limitations in response and peak-current capabilities of existing photomultipliers. Figures 32 and 33 are charts of minimum acceptable pulse widths for the Model 585-66 and 585-63 Detector Heads, respectively.

NOTE

Pulse shape is also a variable.

TYPICAL EXAMPLE

For a Model 585-66 Detector Head, is a pulse width of 1×10^{-6} second acceptable for a charge indication of 1×10^{-8} coulomb? The flash-source output waveform in this case is a square wave. Using the chart in Figure 32 with a charge indication of 1×10^{-8} coulomb, the minimum acceptable pulse width for a square wave is 1.0×10^{-5} second. Therefore, the proposed setup is not satisfactory. Next, use the chart with 1×10^{-6} second. This indicates that 1×10^{-9} is the maximum charge acceptable for this particular pulse shape. Therefore, the system setup must be altered to meet these boundary conditions. Possible solutions might be to alter the source-to-Detector Head distance, to insert a calibrated aperture, reduce the Monochromator slits, etc.

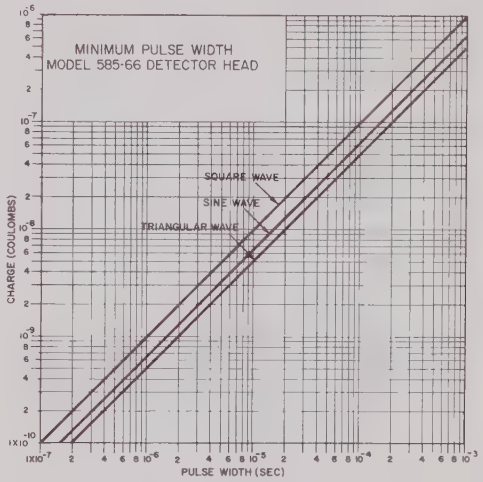


Figure 32. Minimum Pulse Width; Model 585-66 Detector Head.

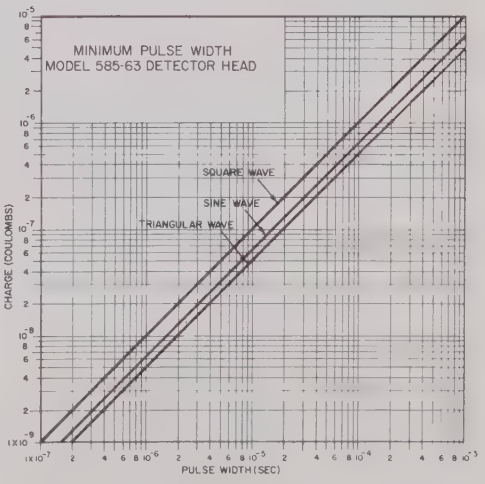


Figure 33. Minimum Pulse Width; Model 585-63 Detector Head.

Measuring Peak Spectral Irradiant Power, Pulse Width, Pulse Shape

Determination of peak spectral irradiant power, pulse width, and pulse shape is identical to measuring integrated spectral irradiant energy with the following exceptions:

(1) Signal switch on Detector Head is switched to EXT position.

(2) The "external" output is connected through the SIGNAL BNC connector to a suitable oscilloscope using a termination configuration appropriate to the characteristics of the pulse being measured (see NOTE below).

(3) Pulse width and pulse shape are determined directly from the oscilloscope display.

(4) Peak spectral irradiant power is the peak voltage across the load (read from oscilloscope display), divided by the product of the load and the system sensitivity.

TYPICAL EXAMPLE

What is peak spectral irradiant power of a pulsed light source at 800 mμ whose output gives a 12.5×10^{-3} volt reading across a 50-ohm resistor? System sensitivity is 25 amp/watt/cm^2 -mμ at 800 mμ.

V_p = peak voltage on oscilloscope display in volts

R_L = load resistance in ohms

R_λ = system sensitivity at wavelength λ in A/W/cm^2 - mμ

$$H_{800}\ \text{peak} = \frac{V_p}{R_L \times R_{800}} = \frac{12.5 \times 10^{-3}}{50 \times 25}$$

$$= 1.0 \times 10^{-5}\ \text{W/cm}^2\text{ -m}\mu$$

NOTE

Keep in mind that the High-Sensitivity Detector Head in the oscilloscope output configuration is a true current source within the definition of that term. Thus, one can terminate in any load impedance that does not exceed the current capability and/or frequency response of the photomultiplier (S10 responds to a pulse of 10 nanoseconds risetime or greater, S1 to one of 25 ns or greater). In other words, terminate in a load resistance required to give the required voltage level for oscilloscope operation, keeping in mind the need for lower resistances at higher frequencies to keep RC time constant effects from altering pulse shape.

5.1 GENERAL

Before shipment, each System is calibrated at the factory using calibration equipment traceable to the National Bureau of Standards. Calibration data, necessary to obtain accurate light measurements with the Systems, are furnished.

5.2 MODEL 580 RADIOMETER CALIBRATION

Calibration Data

The Model 580 Radiometer System is supplied as a fully calibrated system. Each Detector Head, Indicator Unit, Narrow-Beam Adapter, and Laser-Beam Sampler is individually calibrated. A curve showing the absolute spectral response is shipped with each Detector Head (Figure 34). In addition, the calibration plate attached to the side of each Detector Head (Figure 35) contains the following data:

(1) A curve showing relative detector response versus wavelength

(2) The value of sensitivity constant K_1 at peak calibration wavelength;

K_1 has units $\frac{\text{amp}}{\text{watt/cm}^2}$ at λ

for meter measurement of irradiant power with steady source

K_1 also has units

$\frac{\text{coulombs}}{\text{joules/cm}^2}$ at λ

for meter measurement of time-integrated irradiant energy with pulsed source

(3) The value of voltage-sensitivity constant K_2 at peak calibration wavelength:

K_2 has units $\frac{\text{volts}}{\text{watts/cm}^2}$

for scope measurement of peak irradiant power with pulsed source

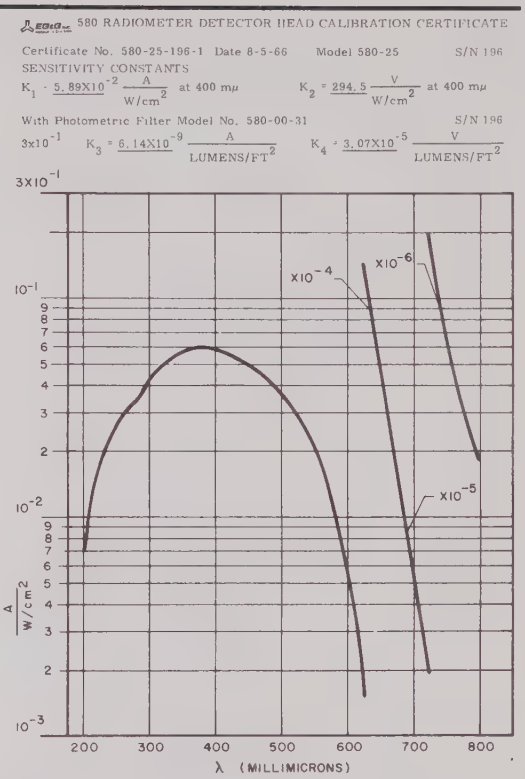


Figure 34. Typical Model 580-20A Series Detector Head Calibration Certificate.

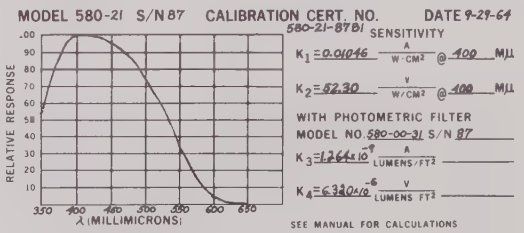

MODEL 580-21 S/N 87 CALIBRATION CERT. NO. 580-21-87D1 DATE 9-29-64
SENSITIVITY
K1 = 0.01046 A/W·CM2 @ 400 MμL
K2 = 52.30 V/W·CM2 @ 400 MμL
WITH PHOTOMETRIC FILTER
MODEL NO. 580-00-31 S/N 87
K3 = 1.264 x 10-9 A/LUMENS/FT2
K4 = 6.340 x 10-6 V/LUMENS FT2
RELATIVE RESPONSE
.00 90 80 70 60 50 40 30 20 10
350 400 450 500 550 600 650
λ (MILLIMICRONS)
SEE MANUAL FOR CALCULATIONS

Figure 35. Typical Model 580-20A Series Detector Head Side Calibration Plate.

Photometric calibration constants are also supplied where applicable. These are

used in the evaluation of light sources intended for visual application. The constants supplied are:

(1) The luminous-sensitivity constant K_3 with photometric calibration;

K_3 has units $\frac{\text{amp}}{\text{lumen/ft}^2}$

for meter measurement of luminous power with steady visible source

K_3 also has units $\frac{\text{coulombs}}{\text{lumen-sec/ft}^2}$

for meter measurement of time-integrated luminous energy with pulsed visible source

(2) The voltage-sensitivity constant K_4 with photometric calibration;

K_4 has units $\frac{\text{volts}}{\text{lumen/ft}^2}$

for scope measurement of peak luminous power with pulsed visible source

The response curves and sensitivity constants supplied provide the simple basis on which current and charge measurements (proportional to the light-source output) are converted to irradiant (or luminous) power and energy values.

Model 580-20A Series Detector Head Calibration

The radiometric calibration of a given 580-20A Series Detector Head includes the determination of its sensitivity as a function of wavelength. This is given in amperes per watt per square centimeter by use of the following procedures:

a. Thermopile measurements of relative exit-beam power of a constant light source-Monochromator combination are made at specific wavelengths across useful bandwidth of Detector to be calibrated. This bandwidth would correspond to: S5, S20, S1, UV, or other spectral responses depending on photosensitive element.

b. Detector under calibration is then substituted for thermopile at Monochromator exit optics, and measurements are taken at same wavelength settings used with thermopile.

c. The ratio of detector current/thermopile voltage at corresponding wavelength settings provides data for relative spectral response of Detector under calibration.

d. An irradiance source and a narrowband interference filter are then used to produce a known amount of power at a known wavelength at a set distance by a calibrated thermopile traceable to the National Bureau of Standards. A Detector Head is placed in same position with diffuser fully illuminated. The current response of Detector under calibration to output of irradiance source is used with thermopile reading and thermopile calibration constant ($\mu v/\mu w/cm^2$) to calculate absolute Detector sensitivity at calibration wavelength (amperes per watt per centimeter^2 -mμ).

This establishes K_1 and K_2 for individual Detector.

e. The absolute sensitivity constant for Detector under calibration is then applied to relative sensitivity points to provide absolute spectral-sensitivity curve unique to individual Detector.

The photometric calibration is normally supplied with the 580-25A Detector Head. In this case, the spectral response of the S5 photodiode is filter-corrected to approximate the standard luminosity response. Detector calibration in this case includes the determination of Detector response to a known value of flash energy from a standard xenon lamp whose output characteristics have been certified by the National Bureau of Standards. The values of K_3, the luminous-sensitivity constant, and K_4, the related voltage-sensitivity constant, are unique to each Detector Head and Photometric Filter combination.

Aperture calibration is in accordance with the following. Using an irradiance source, the initial aperture indication is set to a convenient value by observing the Indicator Unit and adjusting the position of the Detector Head. For each consecutive setting of the APERTURE MULTIPLIER switch, the applicable aperture trimmer is adjusted to give the proper ratio to the original setting.

Model 580-11A Indicator Unit Calibration

To eliminate or minimize troubles during calibration the following functional checks of the Unit are made:

a. Check of mechanical zero of meter
b. Check of meter down-scale leakage
c. Check of COMPENSATION circuit
d. Check of charge sequence
e. Check of X3 MULTIPLIER scaling
f. Check of CURRENT DAMPING control
g. Check of ZERO ranging
h. Check of panel lights

For current calibration, the current-range potentiometers for the X 10^{-6} through X 10^{-11} current-range scales are adjusted for exact full-scale meter deflection using a precise current source (0.1%).

For charge calibration, the charge-range potentiometers for the X 10^{-7} through X 10^{-11} change-range scales are adjusted for exact full-scale meter deflection using a precise charge source (0.1%).

Model 580-00-11 Narrow-Beam Adapter Calibration (See Figure 36)

The calibration of the Narrow-Beam Adapter relates to the following equation that expresses the transmission at any wavelength using an irradiance source of light:

$$\tau = \frac{E_2}{E_1} \frac{1}{A} \frac{(d_2)^2}{(d_1)} = w/cm^2/w$$

where

E_1 = output of Detector Head at a wavelength determined by the filter used

E_2 = output of Detector Head with the Narrow-Beam Adapter and precision aperture at the same wavelength (same filter)

A = area of precision aperture

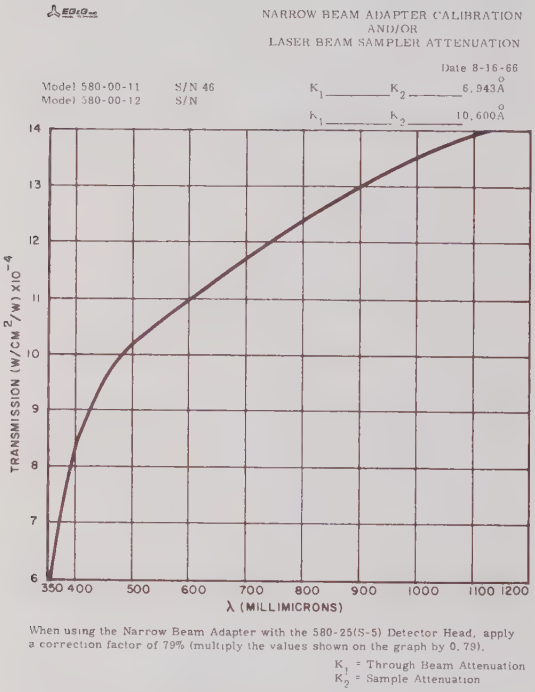

NARROW BEAM ADAPTER CALIBRATION
AND/OR
LASER BEAM SAMPLER ATTENUATION
Date 8-16-66
Model 580-00-11 S/N 46
Model 580-00-12 S/N
K1 K2 6,943Å
K1 K2 10,600Å
TRANSMISSION (W/CM2/W) X10-4
λ (MILLIMICRONS)
When using the Narrow Beam Adapter with the 580-25(S-5) Detector Head, apply a correction factor of 79% (multiply the values shown on the graph by 0.79).
K1 = Through Beam Attenuation
K2 = Sample Attenuation

Figure 36. Typical Model 580-00-11 Narrow-Beam Adapter Calibration Certificate.

d_1 = distance from light source to first diffuser of Detector Head

d_2 = distance from light source to first diffuser of Narrow-Beam Adapter

Conversion of Data

Measurements are made with the Model 580 Radiometer in terms of a meter or recorder display of charge or current, or an oscilloscope display of voltage waveforms. These measurements are directly related to the source output, and conversion to irradiant (or luminous) units is made by application of the proper calibration constants and multipliers. The following data-conversion formulae apply for any monochromatic irradiance of wavelength (radiometric), or any illuminance from a source intended for a visual application (photometric) where:

I_m = current measured on meter in amperes

Q_m = charge measured on meter in coulombs

V_m = peak voltage measured on oscilloscope

M_a = value of Detector Aperture Multiplier

M_v = voltage multiplier setting on Detector

when

$M_v = 1$, $R_{load} = 5k\Omega$;

$M_v = 10$, $R_{load} = 500\Omega$;

$M_v = 100$, $R_{load} = 50\Omega$

$K_{1\lambda}$ = radiometric sensitivity constant for Detector Head at any wavelength in:

$$\frac{\text{amp}}{\text{watt/cm}^2} \quad \text{or} \quad \frac{\text{coulombs}}{\text{joule/cm}^2}$$

$K_{2\lambda}$ = radiometric voltage-sensitivity constant for Detector Head in:

$$\frac{\text{volts}}{\text{watt/cm}^2} = K_{1\lambda} \, R_{load}$$

K_3 = photometric sensitivity constant for Detector with luminosity filter in

$$\frac{\text{amp}}{\text{lumen/ft}^2} \quad \text{or} \quad \frac{\text{coulombs}}{\text{lumen-sec/ft}^2}$$

K_4 = photometric voltage-sensitivity constant for Detector with luminosity filter in

$$\frac{\text{volts}}{\text{lumen/ft}^2} = K_3 \, R_{load}$$

RADIOMETRIC	PHOTOMETRIC
Monochromatic Irradiance	Any Visual Source

STEADY SOURCE

Average Irradiant Power (P)	Average Luminous Power (F)
$P = \frac{I_m M_a}{K_{1\lambda}}$ in $\frac{\text{watts}}{\text{cm}^2}$	$F = \frac{I_m M_a}{K_3}$ in $\frac{\text{lumens}}{\text{ft}^2}$

PULSED SOURCE

Integrated Irradiant Energy (H_i)	Integrated Luminous Energy (E_i)
$H_i = \frac{Q_m M_a}{K_{1\lambda}}$ in $\frac{\text{joules}}{\text{cm}^2}$	$E_i = \frac{Q_m M_a}{K_3}$ in $\frac{\text{lumen-sec}}{\text{ft}^2}$

Peak Irradiant Power (P)	Peak Luminous Power (F)
$P = \frac{V_m M_a}{K_{2\lambda}}$ in $\frac{\text{watts}}{\text{cm}^2}$	$F = \frac{V_m M_a}{K_4}$ in $\frac{\text{lumens}}{\text{ft}^2}$

Additional information can be obtained when pulsed-light waveforms are scope displayed, such as:

a. The wave shape can be determined.

b. The pulse rise time, fall time, and duration can be measured directly from trace against oscilloscope time base.

c. Peak signal voltage can be observed for conversion to peak-power measurements for repetitive waveforms or peak-power measurements for transient pulses.

Relative Measurements

Relative measurements of any source irradiance can be made with the Model 580 Radiometer provided the source spectrum is covered by the Model 580-20A Series Detector Heads selected.

Photometric Measurements

Detectors supplied with a photometric calibration have a net spectral response (detector-photometric filter) which closely follows the standard luminosity curve. Model 580 measurements with sources intended for visual applications are therefore absolute measurements.

Radiometric Measurements

Proper Model 580 measurements are absolute where source irradiance is monochromatic and of a known wavelength. Absolute measurements with chromatic sources require knowledge of the spectral characteristics of the source (irradiant power of energy versus wavelength). Total absolute power of energy of a chromatic source is the summation of the incremental contribution of the power or energy at each wavelength. This measurement is best performed with an instrument like the EG&G Model 580/585 Spectroradiometer. The Model 580/585 operates compatibly with the Model 580 Radiometer to directly characterize an irradiant source. Absolute measurements in watts (or joules) per cm^2 -mμ can be made at intervals across the Model 580 spectral range. The summation of these incremental readings is the total power or energy of the chromatic source as seen by the Detector Head.

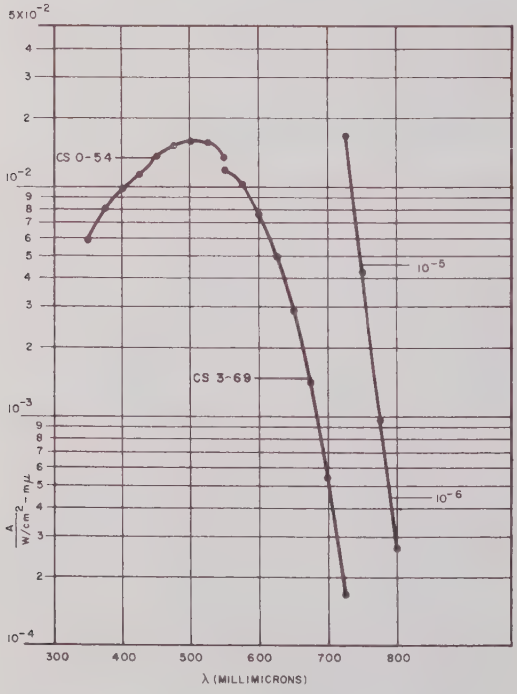
5.3 580/585 SPECTRORADIOMETER CALIBRATION

Calibration Data

The Calibration Data is supplied for the Model 580/585 Spectroradiometer System

on a calibration chart as shown in Figure 37. The charts contain all the model and serial numbers of all the units/components used in the calibration.

The data are obtained by using a NBS standard light source at a specified distance from the first diffuser surface of the complete system to be calibrated. Using the calibration of the lamp given by the National Bureau of Standards and the current shown on the Indicator Unit at each wavelength, a value of amp/watts per cm^2 -mμ can be established using the Model 585-20-22 Fixed Slits for the visible and infrared regions and the Model 585-20-21 Fixed Slits for the UV region. This calibration can be transferred to any of the other slits by simply setting up a steady light source with the calibrated slits and taking the current readings. Readings derived with the new pair of slits establish a ratio which permits the use of the calibration curve. This type of transfer calibration can also be done with filters. This is perhaps the simplest type of calibration with any of the systems used. To re-establish a familiarity with the Model 580-20A Series Detector Head and Model 580-11A Indicator Unit calibrations, see paragraph 5.2.



SPECTRORADIOMETER CALIBRATION

Certificate No. 58522-114-1

	Model No.	S/N
Monochromator Housing Assembly	585-11	8
Monochromator Grating	585-22	5
Monochromator Slits Entrance 5.36mm Exit 3.00 mm	585-20-21	N/A N/A
Beam Input Optics	585-31	3
Filters (corning) CS NO. 0-54 350 mμ to 550 mμ CS NO. 3-69 550 mμ to 800 mμ	585-20-11 585-20-12	3 3
Detector Head	580-22	114
Narrow Beam Adapter	580-00-11	4

Calibrated by_____ Date 5-12-65

Figure 37. Typical Model 580/585 Spectroradiometer Calibration Certificate.

6.1 GENERAL

Maintenance other than external cleaning of system components is not advised. Surface mirrors, extremely critical internal adjustments, etc., could be damagingly and permanently altered if maintenance is attempted by other than factory specialists.

6.2 CLEANING

If cleaning of external surfaces is necessary, care should be exercised to prevent water, cleaning liquids, and other foreign substances from working or leaking through assembly housings to internal components. Diffuser discs, glass input optics, and beam input lenses should be cleaned with a commercially recognized lens cleaner only.

NOTE

Assemblies and components not in use should be stored in their respective protective cases.

6.3 SCHEMATICS

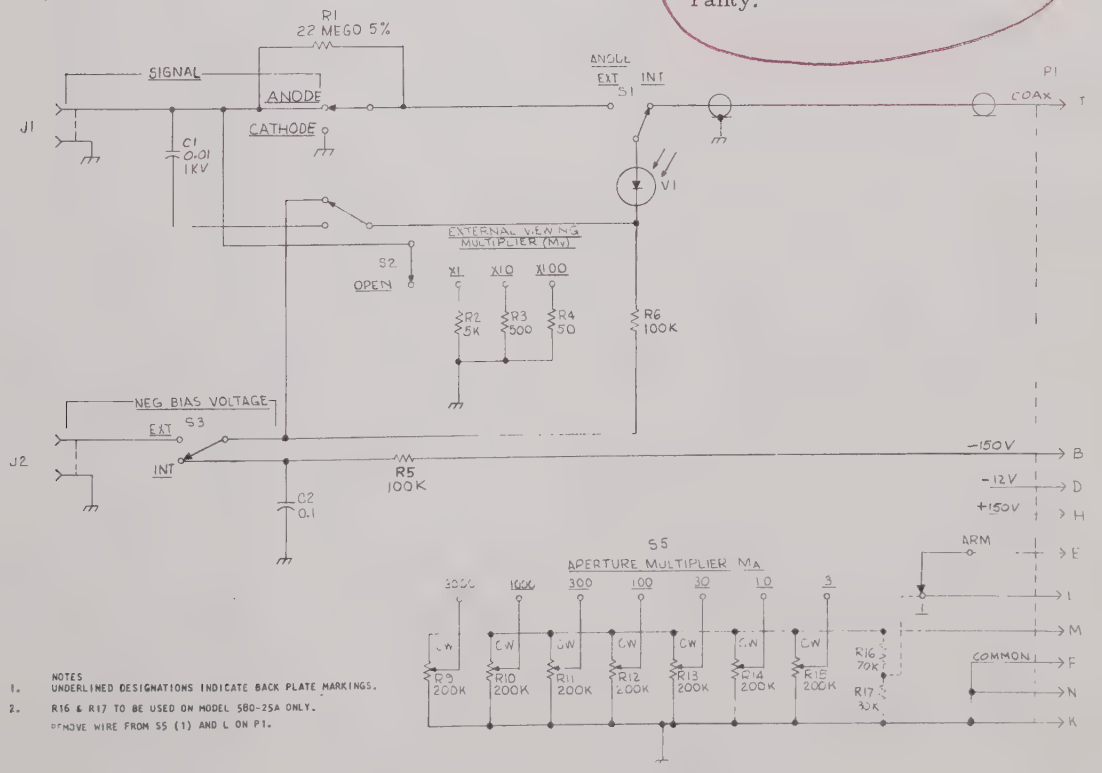
Schematic diagrams for all electronic components of the Systems are provided at the end of this section.

6.4 EQUIPMENT RETURN

If it is necessary to return equipment to the factory for maintenance or calibration, please furnish information as to difficulty, calibration desired, etc.

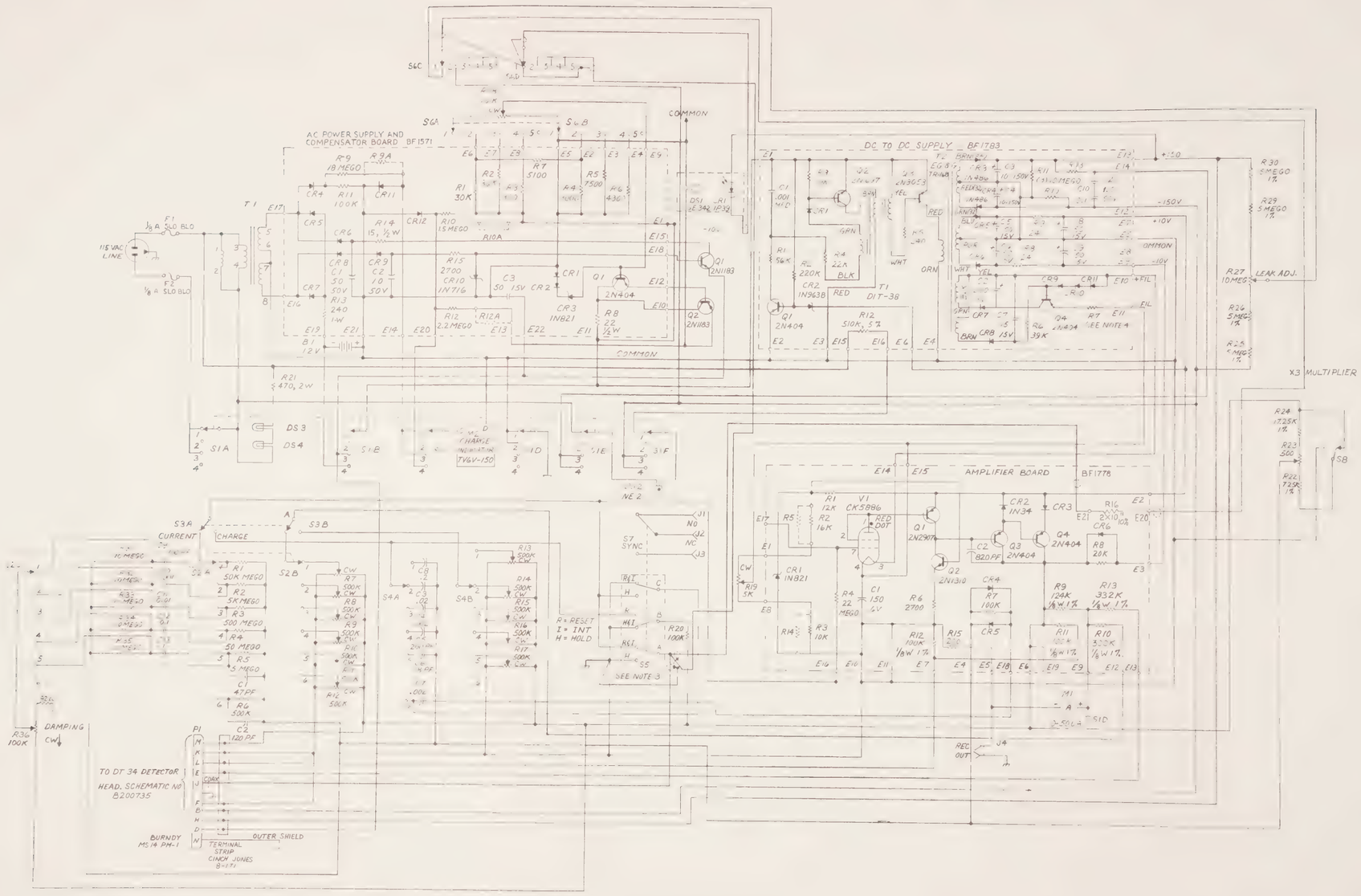
NOTE

Opening Indicator Unit or Detector Head voids warranty.



NOTES
1. UNDERLINED DESIGNATIONS INDICATE BACK PLATE MARKINGS.
2. R16 & R17 TO BE USED ON MODEL 580-25A ONLY.
REMOVE WIRE FROM S5 (1) AND L ON P1.

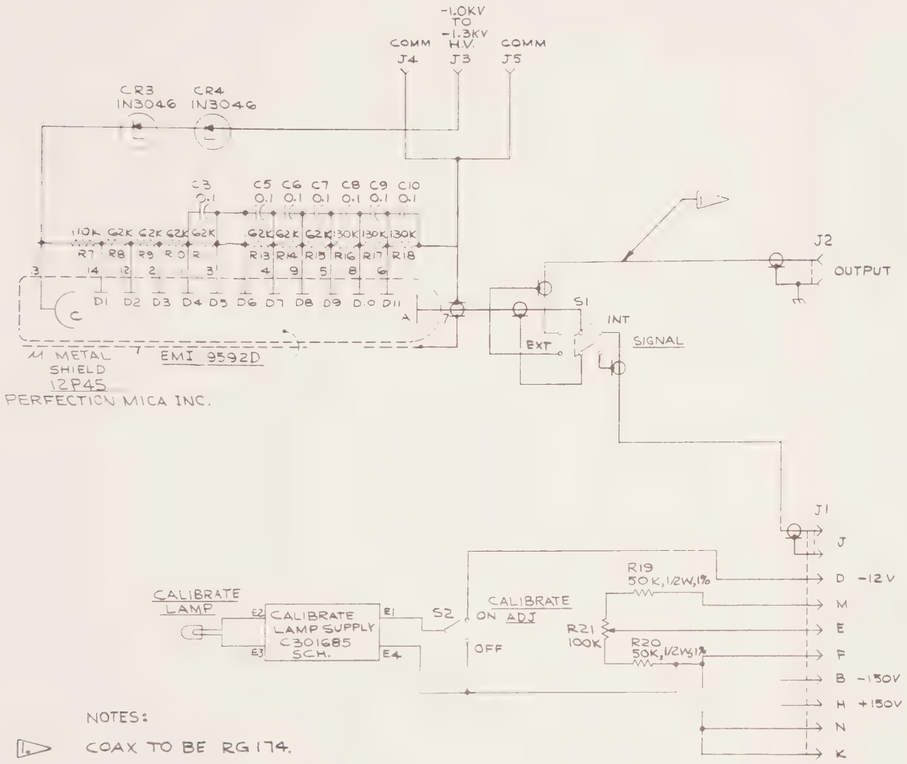
Figure 38. Schematic Diagram, Model 580-20A Series Detector Heads.



NOTES

1. R9A, R10A, R12A TO BE ADDED WHEN LARGER BATTERY IS USED TO HOLD CHARGING TIME VALUES ARE EQUAL TO R9, 10 & 12 RESPECTIVELY.
2. R5&R16 ON AMPL. BD. ARE TO ALLOW FOR ASSEMBLY ADJUST OF CIRCUIT BIAS.
3. SWITCHES S5 & S7 SHOWN INTEGRATE POSITION.
4. R7 FOR ASSEMBLY ADJUST OF FILAMENT VOLTAGE (10-30Ω).
5. THIS NETWORK IS ADDED ACROSS EACH OF THE VICTOREEN RESISTORS ON THIS SECTION OF S3 (A) WITH THE EXCEPTION OF POS 06.

Figure 39. Schematic Diagram, Model 580 – 11A Indicating Unit.



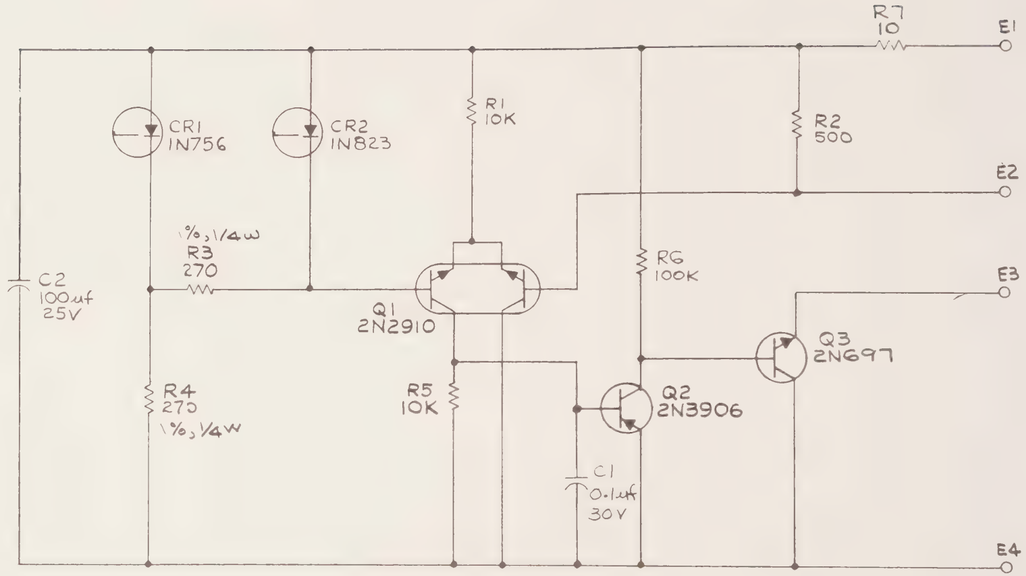
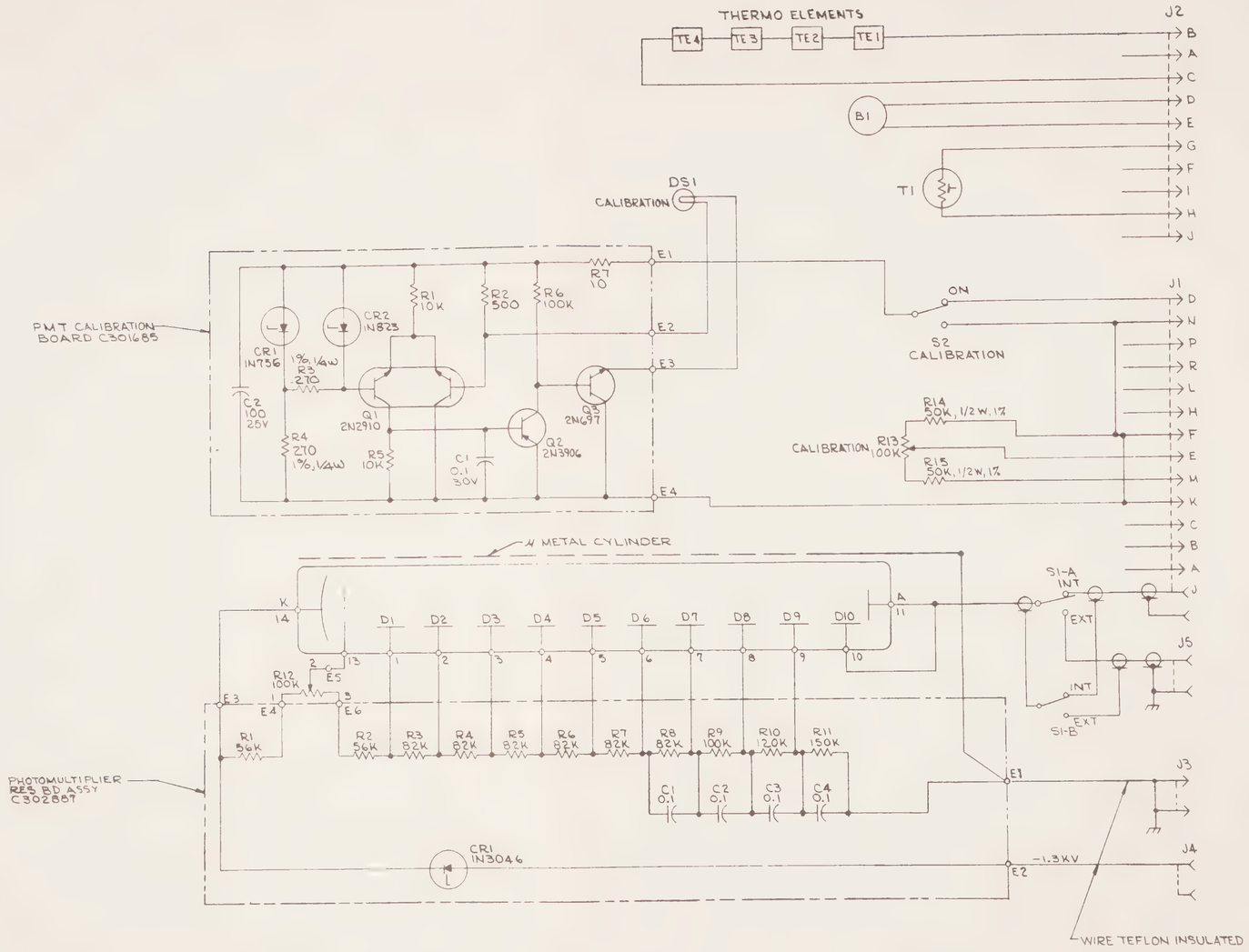
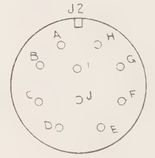
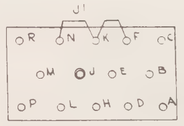


Figure 40. Schematic Diagram, Model 585–66 High-Sensitivity Detector Head.





REAR VIEW
MS3102A-18P



REAR VIEW
MS14PM-1

NOTES:
1. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ALL RESISTORS ARE 1/4W 5% AND IN OHMS UNLESS OTHERWISE SPECIFIED.

Figure 41. Schematic Diagram, Model 585–63 High-Sensitivity Detector Head.

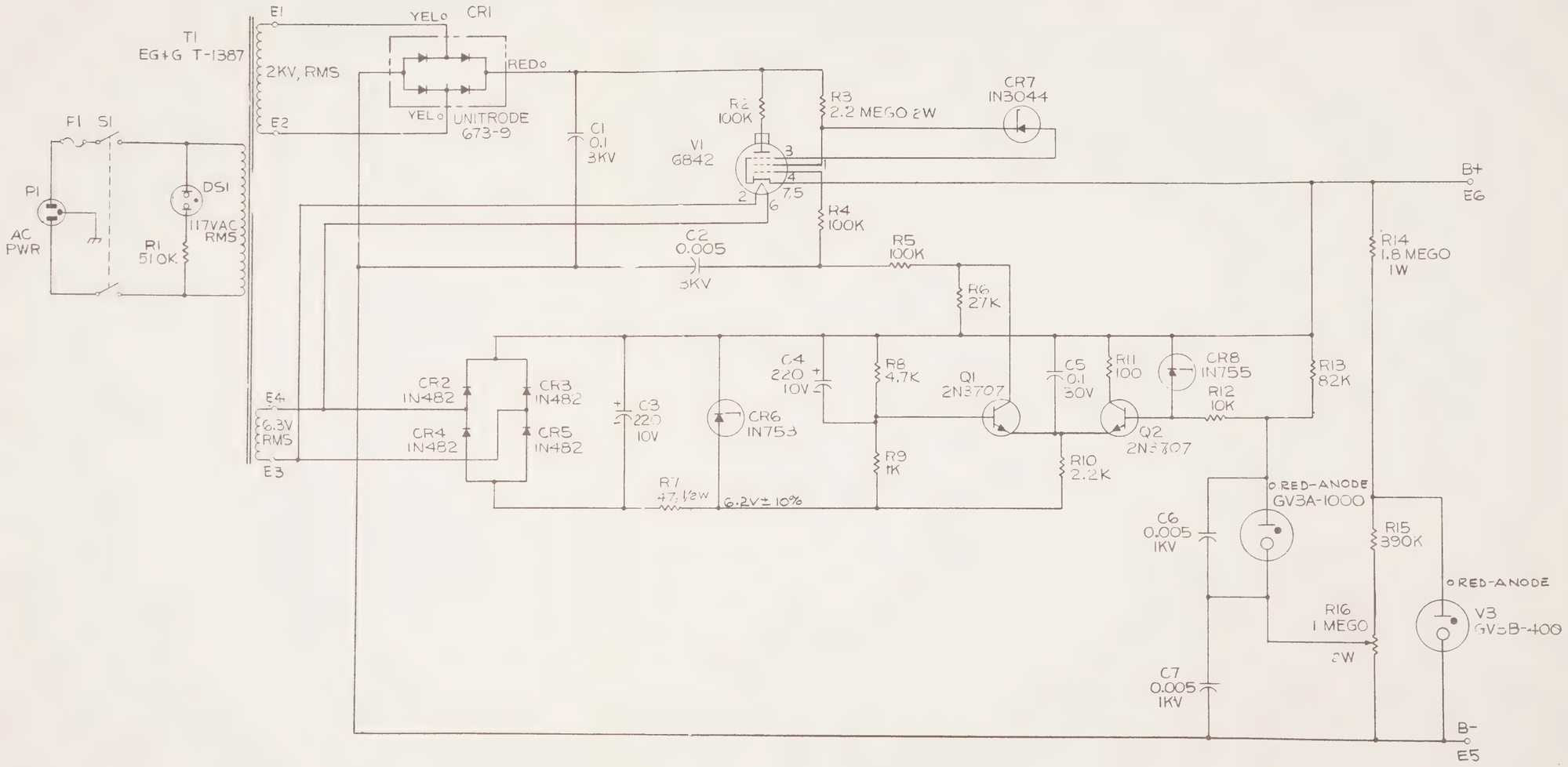


Figure 42. Schematic Diagram, Model 580-00-60 Power Supply.

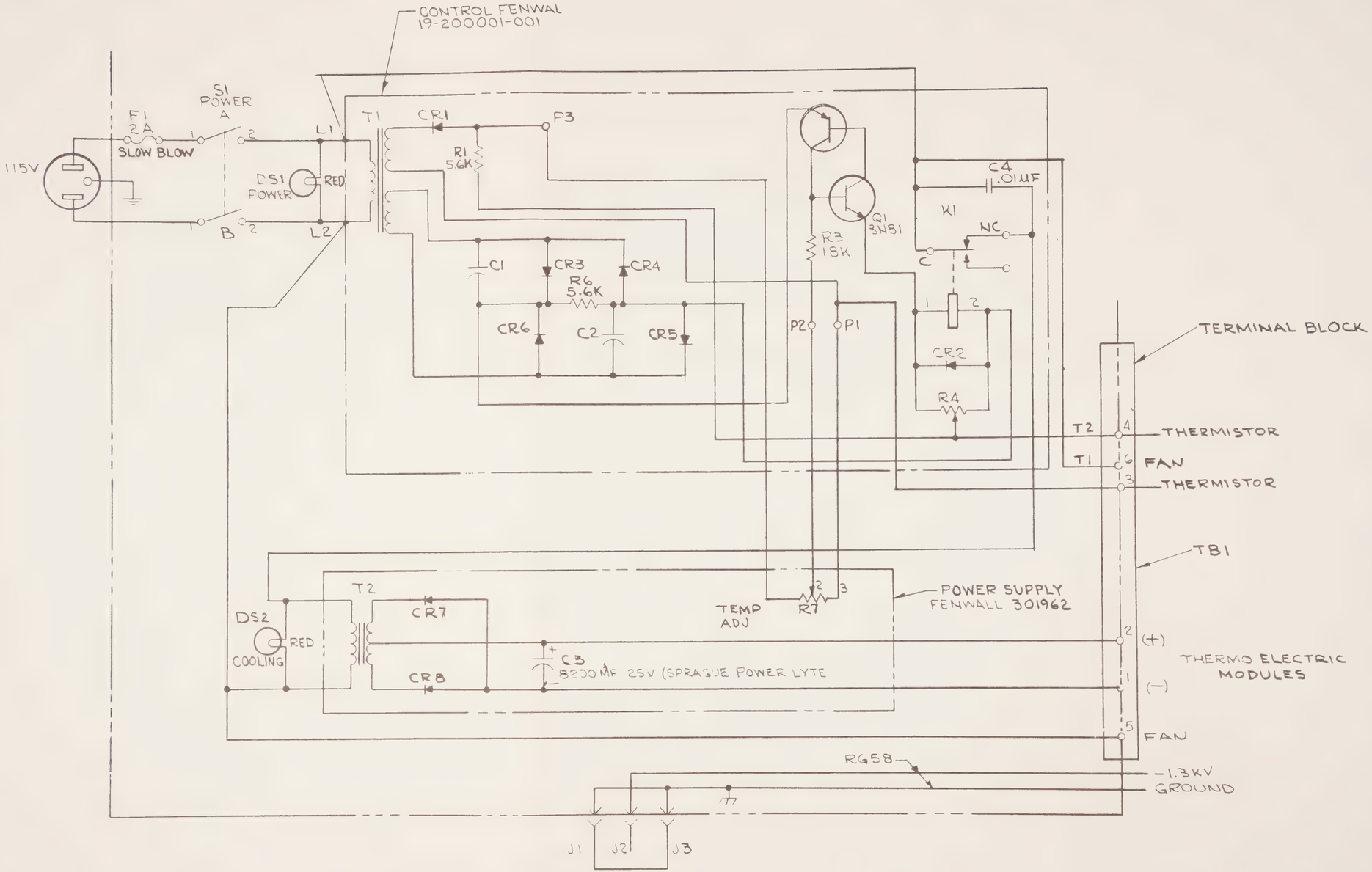


Figure 43. Schematic Diagram, Model 585-00-63 Controller.

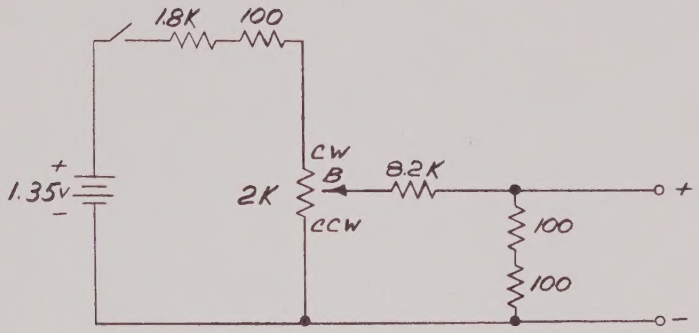


Figure 44. Model 585-11-11 Wavelength Transducer.

MP MASTER
MA29010

EG&G

ALBUQUERQUE BEDFORD BOSTON SALEM LAS VEGAS SANTA BARBARA SAN RAMON WASHINGTON